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D'APPOLONIA CONSULTING ENGINEERS INC PITTSBURGH PA
NATIONAL DAM INSPECTION PROGRAM. GREEN LANE RESERVOIR DAM (NDI --ETC(U)
JUL 79

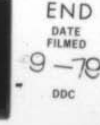
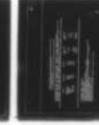
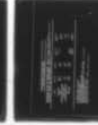
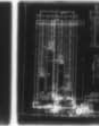
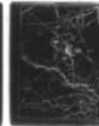
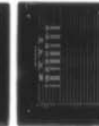
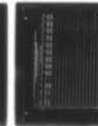
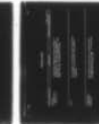
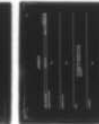
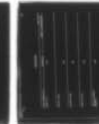
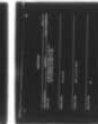
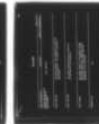
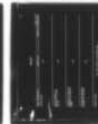
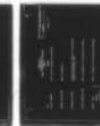
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DELAWARE RIVER BASIN
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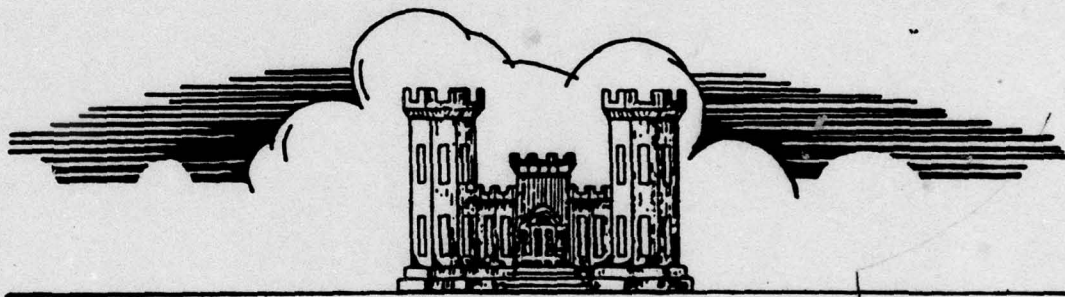
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GREEN LANE RESERVOIR DAM

NDI - PA 00618
PA DER 46-250

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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Prepared By

O'BRIEN & GERE

Justin & Courtney Division
PHILADELPHIA, PENNSYLVANIA
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Contract No: PA CW31-79-C-0014
FOR

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT CORPS OF ENGINEERS
BALTIMORE, MARYLAND
21203

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JULY 1979

Contract (DACW31-79C-0014)
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Engineers, Pittsburgh, PA
Per Ted Greenfel
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National Dam Inspection Program.
Green Lane Reservoir Dam (NDI - PA
00618 PA DER 46-250), Delaware River
Basin, Perkiomen Creek, Montgomery
County, Pennsylvania. Phase I Inspection Report.

DELAWARE RIVER BASIN

Name of Dam: Green Lane Reservoir Dam
County & State: Montgomery County, Pennsylvania
Inventory Number: PA00618

11 Jul 79

12 93 p.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

15 DACW31-79-C-0014

Prepared by:

O'BRIEN & GERE ENGINEERS, INC
JUSTIN & COURTNEY DIVISION

For

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

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PREFACE

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This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PHASE I REPORT

NATIONAL DAM INSPECTION

Name of Dam: Green Lane Reservoir Dam ID #PA00618
State Located: Pennsylvania
County Located: Montgomery
Stream: Perkiomen Creek
Coordinates: Latitude 40° 20.5, Longitude 75° 28.8'
Date of Inspection: April 10, 1979

ASSESSMENT

Green Lane Reservoir Dam is a concrete gravity structure about 780 feet long and 87 feet high. A 424 foot long ungated spillway is located along the length of the dam. The dam impounds a 814 acre reservoir at normal pool elevation. Storage at maximum pool (Elevation 297.0) is about 25,114 acre-feet. The dam is classified as "Intermediate" size.

The dam and impoundment are owned by the Philadelphia Suburban Water Company; the facility is operated to provide a source of water for the Owner's distribution system.

The dam is classified as a "High" hazard structure; the Spillway Design Flood is the Probable Maximum Flood (PMF). A review of the results of the hydrologic and hydraulic analyses indicates that the spillway is capable of passing about 76 percent of the PMF before overtopping of the non-overflow section would occur. The spillway is considered to be "Inadequate" for passing the PMF; however, the spillway is not considered "Seriously Inadequate" since it is capable of passing more than 50 percent of the PMF.

Stability analyses were performed for both the spillway and non-overflow sections for the anticipated range of loading conditions. A review of the results indicates that tension is developed in all sections analyzed for the PMF loading condition. The sliding safety factor developed is less than 3 for the non-overflow section for the PMF loading.

Based on visual observations and review of the information obtained from the Pennsylvania Department of Environmental Resources, Green Lane Reservoir Dam appears to be in good condition.

Recommendations & Remedial Measures are as follows:

a. Facilities

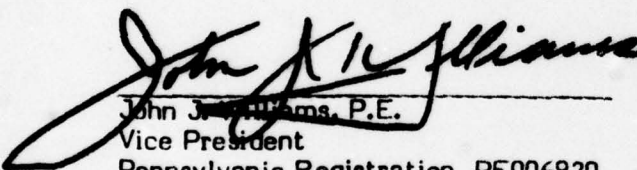
1. A thorough investigation of the channel bottom immediately downstream from the spillway should be performed to determine the source of the sand and gravel deposits observed during the visual inspection.

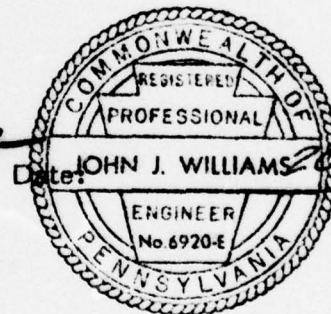
2. Seepage occurring at the upstream junction of the 48-inch diameter reservoir drain line and gatehouse should be visually inspected on a regular basis to note any changes in quantity of flow.
3. The downstream slope of the south abutment should be kept free of any vegetation that might hinder the observation of developing conditions detrimental to the safety of the dam.

b. Operation & Maintenance Procedures

1. Failure of the dam could cause extensive property damage and possible loss of life downstream. According to the Owner's representative, a formal procedure of observation and warning during periods of high precipitation is being developed. This procedure should include a method of warning residents located downstream that high flows are expected along Perkiomen Creek. If abnormally high flows are expected, procedures for evacuating people within the flood plain should be implemented.
2. The Owner should have the facility inspected by an experienced professional licensed engineer on an annual basis.

O'BRIEN & GERE ENGINEERS, INC.
JUSTIN & COURTNEY DIVISION


John J. Williams, P.E.
Vice President
Pennsylvania Registration PE006920

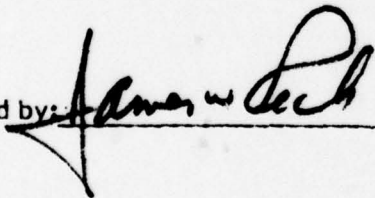


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JOHN J. WILLIAMS

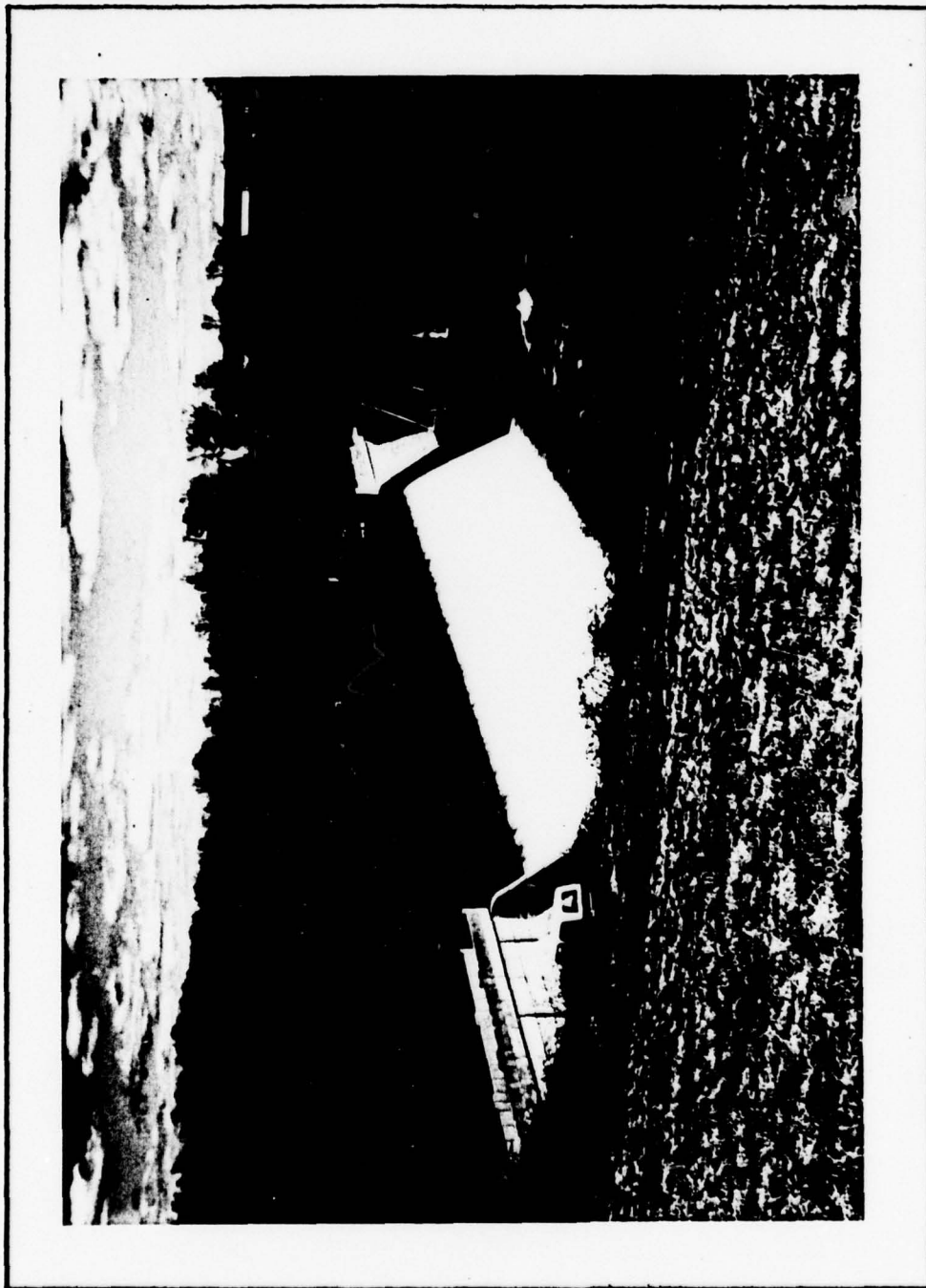
July '79

Approved by:



Date:

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OVERVIEW
GREEN LANE RESERVOIR DAM, MONTGOMERY COUNTY, PENNSYLVANIA

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
GREEN LANE RESERVOIR DAM NDI ID #PA00618
SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of this inspection is to determine if Green Lane Reservoir Dam constitutes a hazard to human life or property.

1.2 Description of Project. (Supplemented by information obtained from the Pennsylvania Department of Environmental Resources (DER), Division of Dam Safety, Harrisburg, PA.) *ABSTRACT*

a. Dam and Appurtenances. → Green Lane Reservoir Dam is a concrete gravity structure approximately 780 feet long, with a maximum height of about 87 feet. A 424 foot ungated spillway (crest Elevation 286.0) is centered along the length of the dam.

→ The non-overflow section (Elevation 297.0) has a top width of 14 feet. Below Elevation 281.0, the upstream slope is battered on a 1 horizontal to 14.55 vertical (1H:14.55V); the downstream slope is 1H:1.35V. Both faces are vertical above Elevation 281.0. A 3-foot high parapet has been constructed on the non-overflow section. The dam is founded on firm bedrock. The foundation rock was mass grouted to depths up to 30 feet to reduce loss of water through seepage. The non-overflow sections are founded in rock on both sides of the stream valley. This rock has also been grouted to reduce seepage.

→ The spillway is a concrete Ogee with a maximum height of approximately 77 feet. A flip bucket type energy dissipator with a 25-foot radius has been constructed at the toe of the spillway.

→ Training walls extend downstream from the dam on both sides of the spillway. The walls are constructed to Elevation 255.0 and retain and protect the channel banks immediately below the dam.

→ A water intake facility is located in the non-overflow section at the north end of the spillway. The intake is separated into two parallel chambers by an internal wall. Flow can be directed between the two chambers by a 36-inch sluice gate positioned in the wall. Openings at four different stages control water entering the intake. Each opening is fitted with a removable screen to prevent debris from entering.

ABSTRACT

The operating mechanisms for the four 36-inch wide by 48-inch high sluice gates, the single 36-inch sluice gate and the frame assemblies used to raise and lower the debris screens are located on the crest of this section of the dam. A small structure, housing compressor equipment used for aeration, is also positioned on the crest.

Four pipelines (two 36-inch diameter and two 48-inch diameter) are located at the downstream base of the intake structure. The pipelines were originally used for flow diversion during construction. All of the pipe openings are sealed at the upstream face of the intake except for one 48-inch diameter pipe which serves as a reservoir drain. The two 36-inch diameter pipelines are valved at the exit from the intake, with the operating mechanisms located on the crest of the dam.

The four pipelines extend downstream to the gatehouse located at the toe of the dam. The two 36-inch diameter lines are used to release a pre-determined discharge to the downstream channel. Two valves (one 20-inch butterfly and one 20-inch gate) are positioned in series on each 36-inch diameter line within the gatehouse; both are operated manually. The 48-inch pipeline serving to drain the reservoir is controlled by two 48-inch gate valves in series. The valves, also located in the gatehouse, can be operated electrically or manually. Electrical service to the operating mechanisms is 220 volts. The second 48-inch diameter pipeline is sealed at the upstream side of the gatehouse.

The pipelines extend from the gatehouse and are routed back to the downstream channel below the spillway. The pipe outlets project through the face of the north training wall with inverts at Elevation 221.0.

b. Location. Green Lane Reservoir Dam is located on Perkiomen Creek, about 2,000 feet upstream of the borough limits of Green Lane in Montgomery County, Pennsylvania. The dam site is shown on the USGS Perkiomenville Quadrangle (7½ min. series) at coordinates N 40° 20.5', W 75° 28.8'. A regional vicinity map, developed from the applicable quadrangle sheets is included as Plate 1, Appendix E.

c. Size Classification. The maximum height of the dam is about 87 feet and the maximum reservoir storage (to the top of dam, Elev. 297) is approximately 25,100 acre-feet. The dam is, therefore, in the "Intermediate" size classification.

d. Hazard Classification. Failure of the dam could result in the loss of many lives and extensive property damage in the Borough of Green Lane (located about 2,000 feet downstream) and other communities further downstream. About 150 dwellings are located within the first mile downstream of the dam. The dam is, therefore, classified in the "High" hazard category.

e. Ownership. The dam is owned by the Philadelphia Suburban Water Company. Arrangements for the inspection were made with Mr. Robert Luska, Chief Engineer, Philadelphia Suburban Water Company (215-525-1400). Correspondence may be addressed to: Philadelphia Suburban Water Company, 762 Lancaster Avenue, Bryn Mawr, PA 19010.

f. Purpose of Dam. The dam was constructed to provide storage for the Owner's water distribution system. Fishing in the reservoir is permitted on a controlled access basis.

g. Design and Construction History. Green Lane Reservoir Dam was designed by Albright & Friel, Consulting Engineers, Philadelphia, PA., for the Philadelphia Suburban Water Company. The permit for construction of the dam was issued by the Pennsylvania Water and Power Resources Board on August 12, 1953; the dam became operational in 1957. The contractor was the J.A. Jones Construction Company, Charlotte, North Carolina. There is no record of any subsequent remedial work performed on the dam.

h. Normal Operating Procedures. The water surface elevation is normally maintained at or near the spillway crest. Releases to the water supply system are provided by means of two 36-inch diameter pipes which discharge water to the channel downstream. The reservoir drain system is exercised annually to reduce sediment build-up in the vicinity of the intake.

1.3 Pertinent Data

a.	<u>Drainage Area</u> (sq. miles)	71
b.	<u>Discharge at Dam site</u> (cfs)	
	Maximum known flood at dam site	11,400
	Elev. 290.05	
	Spillway capacity at maximum pool	
	Elev. 297.0	60,323
c.	<u>Elevations</u> (feet above MSL)	
	Spillway Crest - Normal Pool	286.0
	Top of Non-overflow section	297.0
	Top of Parapet	300.0
	Streambed at dam	210.0+
	Discharge Pipes (invert)	221.0
d.	<u>Reservoir Length</u> (feet)	
	Normal Pool, Elev. 286.0	28,000
	Maximum Pool, Elev. 297.0	30,400
e.	<u>Reservoir Storage</u> (acre-feet)	
	Normal Pool, Elev. 286.0	13,430
	Maximum Pool, Elev. 297.0	25,114

f. Reservoir Surface Area (acres)

Normal Pool, Elev. 286.0	814
Maximum Pool, Elev. 297.0	1,243

g. Dam Data

Type	Concrete Gravity
Length (including spillway)	780 feet
Height (max.)	87 feet
Top Width (non-overflow section)	14 feet
Side slopes (non-overflow section)	1:14.55 upstream
	(below Elev. 281.0)
(both slopes are vertical	1:14.55 upstream
above Elev. 281.0)	(below Elev. 281.0)
Foundation Treatment	Mass grouting

h. Diversion and Regulating Tunnel

Not Applicable

i. Spillway

Type	Ogee
Length	424 feet
Height	77 feet
Control	None - Ungated
Energy Dissipator	Flip bucket

j. Regulating Outlets. Four openings regulated by 48-inch high by 36-inch wide sluice gates are staged vertically in the intake in the non-overflow section. Outlet pipes (two 48-inch diameter and two 36-inch diameter CIP) are located in the base section and extend to the gatehouse. The two 36-inch diameter pipes are used to release stored water to the downstream channel. One 48-inch pipe is used to drain the reservoir, the other is plugged. Each 36-inch pipe is controlled by two 20-inch valves in series, the 48-inch pipe is used to drain the reservoir is controlled by two 48-inch valves in series (see section 1.2.a).

SECTION 2

ENGINEERING DATA

2.1 Design

a. Data Available. The information provided by DER for review of Green Lane Reservoir Dam includes the following:

1. "Application", "Report on Application" and "Permit" to construct Green Lane Dam.
2. "Plans for Green Lane Reservoir" prepared by Albright and Friel, Inc., Consulting Engineers (18 of 18 sheets).
3. Plan and Elevation "Grouting Pattern" prepared by Albright and Friel.
4. "Cross-Section" prepared by Albright and Friel.
5. "Core Drilling Data Sheets, Green Lane Dam".
6. Report entitled "Design Data and Specifications".
7. "Interim Report on Geology, Green Lane Dam, Perkiomen Creek, PA and Supplement", prepared by Frank E. Fahlquist, Consulting Engineer-Geologist, dated November 10, 1951.

b. Design Features. The pertinent structural features are shown in Appendix E, Plates 2 through 8.

2.2 Construction. Based on a review of the drawings provided by DER and observations made during the visual inspection on April 10, 1979, it appears that the dam was constructed as designed.

2.3 Operational Data. An average release of about 16.5 mgd. is required to supply the water distribution system. This quantity of water is diverted from Perkiomen Creek about 17 miles downstream from the dam site at the Wetherill Pumping Station. DER requires a minimum release in addition to the quantity released for the water distribution system of about 11.5 mgd. (.25 cfs/square mile of drainage area) for downstream low flow augmentation.

2.4 Evaluation

a. Availability. All engineering data reproduced herein and used for report preparation were provided by DER and supplemented through interviews with the Owner's representative.

b. Adequacy. The data furnished by DER provided an adequate review of the design hydrologic and hydraulic calculations and stability analyses. The drawings accompanying the calculations are legible and complete.

c. Validity. There is no reason to question the validity of the data available from DER.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General. The observations and comments of the field inspection team are presented in Appendix B. The dam and appurtenances appear to have been constructed in conformance with the design drawings provided by DER.

At the time of the inspection, the reservoir water surface was about 0.3-foot above the spillway crest. No underwater areas were inspected.

b. Dam. Spalling of the concrete surface was noted in a few isolated areas on the downstream face of the north non-overflow section of the dam. A crack in the vertical joint nearest to the north abutment was also evident. However, steel was not exposed at any of these locations and no indications of movement could be detected at the joint.

Several calcification deposits were apparent on the downstream face of both the north and south non-overflow sections of the dam. Seepage, in the form of surface moisture, was noted along a horizontal joint in the south non-overflow section of the dam. The quantity of seepage could not be determined, but was minimal.

The horizontal and vertical alignment of the downstream face, top of the dam and those portions of the upstream face visible above the reservoir surface appears to be good. Slight deviations in alignment were apparent but may be the result of misalignment in form work during construction.

The surface concrete on the crest of the non-overflow section appears to be in good condition. The concrete spillway, as observed from the non-overflow sections, also appears to be in good condition.

Shale outcrops are prominent in the vicinity of the left abutment. The bedding layers, varying in thickness from one-quarter inch to about four inches, are shifted to almost vertical planes. Seepage was noted in rock outcrops at elevations above the reservoir surface. No seepage was detected at either the north or south dam abutment interface.

Shale outcropping located about 500 feet downstream from the dam are bedded in a horizontal position.

c. Appurtenances. The gatehouse is located immediately downstream from the north non-overflow section. The operating mechanisms for the valves on the two 36-inch diameter discharge pipes and the 48-inch diameter reservoir drain pipe are located within this structure. A second 48-inch diameter pipe is sealed off at the upstream end of this building. The equipment appears to be well maintained.

Operating personnel stated that all equipment is operational. Some dampness was noted at the intersection of the 48-inch diameter pipe and the upstream wall of the gatehouse. Operating personnel are aware of this condition and indicated that it has existed over a period of time.

Manual hoists for the sluice gates and supplemental pipe valves are located on the crest of the non-overflow section. The operating handles are stored in a small building located on the dam crest. A frame and electrically operated hoist used to raise and lower the debris screens at the intake are positioned at the upstream face of the section. The equipment appears to be well maintained. Operating personnel stated that this equipment is operational.

A compressor, used to aerate inflow to the intake is located in the structure on the dam crest. Operating personnel stated that the compressor equipment is inspected annually by an insurance company.

The training walls on both sides of the spillway appear to be constructed as designed. The horizontal and vertical alignment appears to be good. No evidence of movement or structural cracking was noted.

Electrical service to the site is 440 volts. A stepdown transformer, located adjacent to the gatehouse, reduces the voltage to 220.

e. Reservoir. The reservoir slopes are fairly steep and heavily wooded. No indications of slope instability were noted.

f. Downstream Channel. Sand and gravel deposits, located approximately 200 feet downstream from the spillway toe, were noted within the spillway channel. A thorough investigation to determine the source of these deposits was prevented due to flow conditions at the time of inspection. The deposits could be the result of channel erosion or remnants of former islands in the channel.

The immediate overbanks of the downstream channel are relatively flat and support an established growth or vegetation. A three span vehicular bridge is located about 1,000 feet downstream from the dam. Each span is about 60 feet long with an average height of opening of about 20 feet. A railroad bridge is located about 200 feet downstream from the vehicular bridge. The borough of Green Lane is located about 2,000 feet downstream of the dam and would be susceptible to flooding in the event of dam failure.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedures. The Philadelphia Suburban Water Company operates the Green Lane facility to provide storage for a water distribution system. About 16.5 mgd. are released to the downstream channel. This quantity is diverted from Perkiomen Creek approximately 17 miles downstream from the dam site at the Wetherill Pumping Station. DER requires additional minimum release of about 17.75 cfs (11.5 mgd) for downstream low flow augmentation. Operating personnel attend the facility on a daily basis.

4.2 Maintenance of the Dam. The dam is maintained by the Philadelphia Suburban Water Company. General maintenance is performed on an "as required" basis by operating personnel and consists of maintaining slope protection, storm drainage passages and site appearance. The dam is visually inspected daily.

4.3 Maintenance of Operating Facilities. The operating facilities are maintained by the Philadelphia Suburban Water Company. The operator valves, gate-screens, hoist and compressor are inspected annually. The equipment is visually inspected daily.

4.4 Warning System in Effect. No formal warning system or procedures are in effect for warning downstream residents in case of imminent dam failure, misoperation of equipment or exceptionally high flow volume releases. However, the gatehouse is serviced by local telephone equipment and operators attend the dam on a daily basis. The Owner has engaged the services of a consulting engineer to develop a formal warning system.

4.5 Evaluation of Operational Adequacy. The operation and maintenance procedures for Green Lane Reservoir Dam are considered to be adequate. Upon development of the formal warning system, operating personnel should be trained in the procedures prescribed.

The dam is accessible in all weather conditions for inspection and emergency action.

SECTION 5

HYDROLOGY AND HYDRAULICS

5.1 Evaluation of Features

a. Design Data. According to a review of the data provided by DER, the spillway was designed to discharge a flow of 42,000 cfs. This design discharge was based on the relationship $Q=5000 A$ (A is the drainage area in square miles). This peak flow corresponds closely with the 100 year storm frequency developed by synthetic hydrograph methods from stream flow observations made at Gratersford, Pennsylvania (about 14 miles downstream). The spillway weir was designed to discharge peak flow at a head of 9 feet without resulting in nappe separation.

b. Experience Data. Rainfall and reservoir surface elevation measurements have been recorded by the Owner since the facility became operational in 1957. A review of the records indicate that the maximum recorded reservoir elevation (290.05) occurred in June 1972 during Tropical Storm Agnes. This corresponds to a spillway discharge of about 11,400 cfs.

c. Visual Observations. During the course of the inspection, there were no indications that the spillway would not be capable of performing as designed.

d. Overtopping Potential. Green Lane Reservoir Dam is classified as an "Intermediate" size, "High" hazard dam. The Borough of Green Lane, Pennsylvania is located about 2,000 feet downstream of the dam; about 150 dwellings are located within a mile of the dam. Failure of the dam could result in the loss of many lives and extensive property damage. The Spillway Design Flood (SDF) required is the Probable Maximum Flood (PMF). The PMF hydrograph was developed and flood routed through the reservoir facility with the starting water surface elevation assumed at the spillway crest (Elev. 286.0) and all discharge pipes closed. The HEC-1 Dam Safety Version computer program was used for the hydrograph development and routing procedure. A review of the results indicated the maximum inflow associated with the PMF is about 89,200 cfs and the maximum outflow associated with the PMF is about 82,400 cfs. The maximum reservoir surface elevation under this condition is about 299.0 msl; 2.0 feet above the top of the non-overflow section and 1 foot below top of the parapet. Further review of the hydrologic and hydraulic analysis indicates that the spillway is capable of passing approximately 76 percent of the PMF without overtopping the non-overflow section of the dam. Refer to Appendix C for the hydrologic and hydraulic computations.

e. Spillway Adequacy. The spillway is classified as "Inadequate" since it can not pass the PMF without overtopping the dam. However, the spillway is not "Seriously Inadequate" since it can pass about 76 percent of the PMF without overtopping the non-overflow sections. A spillway is considered to be "Seriously Inadequate" if it is incapable of passing 50 percent of the PMF.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations. No deficiencies which might reduce the structural integrity of the dam were noted during the visual inspection. A thorough inspection of the spillway and flip bucket were not possible due to the flow conditions at the time of the inspection.

b. Design & Construction Data. All available material provided by DER was reviewed. An abbreviated listing of this information is presented in section 2.1.a.

An in-depth report and analyses of the structural stability of the non-overflow and spillway sections were available in the files provided by DER. This information was reviewed and was found to agree closely for similar loading conditions with the analyses performed for this inspection and presented herein as Appendix G. A summary of the information provided by DER is also presented in Appendix G.

c. Operating Records. A review of the operating records made available indicate a maximum recorded water surface Elevation of 290.05. The tailwater elevation at this time was not recorded. The maximum ice thickness is reported to be between 12 and 20 inches.

d. Post-Construction Changes. There are no reports nor is there any evidence that modifications were made to the dam.

e. Seismic Stability. The dam is located in Seismic Zone 1 as shown on the "Seismic Zone map of Contiguous States". Under normal conditions, a dam located in this zone can be considered stable for seismic loading if it can be demonstrated that the dam is stable under the design loading conditions.

f. Evaluation. Stability analyses were made on the spillway and non-overflow sections. The calculations are reproduced in Appendix G. The analyses were performed in accordance with the "Recommended Guidelines for Safety Inspection of Dams" and reflect current design criteria.

A review of the data indicates the flip bucket design was model tested. Therefore, the spillway loading condition at maximum pool was considered for the range of tailwater elevations (hydraulic jump to maximum tailwater rating).

An examination of the results of the structural stability analyses for the non-overflow and spillway sections indicates that the stability requirements relative to overturning are not met for the PMF loading condition; the resultant is located outside the middle third of base width. In addition, the sliding factor of safety for the non-overflow section, PMF condition, does not meet the Corps of Engineers requirement of a minimum value of 3. However, based on the results of the analyses performed herein for the PMF loading, and the relatively minor adverse conditions developed for sliding and base pressures, further investigations are not warranted.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety. The visual inspection of the dam and appurtenances and review of material provided by DER indicates that the structure is in good condition and was built in general compliance with the drawings. Deposits of sand and gravel, however, were observed in the channel immediately downstream from the spillway. Erosion of the channel bed at this location may be occurring.

Based on review of the results of the hydrologic and hydraulic calculations, the spillway is capable of passing about 76 percent of the SDF which is the PMF without overtopping the dam. Therefore, the spillway is considered to be inadequate but not seriously inadequate. Cavitation may develop for flows exceeding approximately 90 percent of the PMF.

The resultant of forces is not located in the middle third of the base widths (spillway and non-overflow section) for the PMF loading condition. Tension is developed in the upstream face of the structure. In addition, the safety factor for sliding (non-overflow section, PMF condition) does not meet the minimum of 3 as prescribed by the Corps of Engineers. However, based on the results of the analyses performed herein for the PMF loading, and the relatively minor adverse conditions developed for sliding and base pressures, further investigations are not warranted.

b. Adequacy of Information. The information made available by DER and supplemented by the Owner's representative is considered to be adequate to make a Phase I evaluation of the dam.

c. Urgency. The recommendations presented in Section 7.2 should be implemented as soon as possible.

d. Necessity for Further Investigation. A physical inspection of the foundation area immediately downstream of the spillway should be made to assess the extent of any erosive damage that might have occurred.

7.2 Recommendations, Remedial Measures

a. Facilities

1. A thorough investigation of the channel bottom immediately downstream from the spillway should be performed to determine the source of the sand and gravel deposits observed during the visual inspection.
2. Seepage occurring at the upstream junction of the 48-inch diameter reservoir drain line and gatehouse should be visually inspected on a regular basis to note any changes in quantity of flow.

3. The downstream slope of the south abutment should be kept free of any vegetation that might hinder the observation of developing conditions detrimental to the safety of the dam.

b. Operation & Maintenance Procedures

1. Failure of the dam could cause extensive property damage and possible loss of life downstream. According to the Owner's representative, a formal procedure of observation and warning during periods of high precipitation is being developed. This procedure should include a method of warning residents located downstream that high flows are expected along Perkiomen Creek. If abnormally high flows are expected, procedures for evacuating people within the flood plain should be implemented.
2. The Owner should have the facility inspected by an experienced, professional engineer on an annual basis.

APPENDIX

A

Check List Engineering Data
Design, Construction, Operation
Phase I

NAME OF DAM Green Lane Reservoir Dam
ID # PA00618

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

Sheet 1 of 4

ITEM
AS-BUILT DRAWINGS
REMARKS
No "as built" drawings are available.

REGIONAL VICINITY MAP
Refer to Appendix E.

CONSTRUCTION HISTORY
Available information relative to construction history was provide by DER.

TYPICAL SECTIONS OF DAM
Refer to Appendix E for construction drawing.

OUTLETS - PLAN
DETAILS
CONSTRAINTS
Refer to Appendix E for construction drawings.

DISCHARGE RATINGS
Refer to Appendix C.

RAINFALL/RESERVOIR RECORDS
Rainfall/reservoir records are maintained by the owner.
The maximum reservoir elevation was recorded during Tropical Storm Agnes, June 1972.

ITEM	REMARKS
DESIGN REPORTS	Design reports were included with the dam application submittal and were made available by DER .
GEOLOGY REPORTS	Geology reports were included with the dam application submittal and were made available by DER.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Data was made available by DER. No data available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Boring logs were included with the construction drawings.
POST-CONSTRUCTION SURVEYS OF DAM	None recorded.
BORROW SOURCES	N/A

ITEM	REMARKS
MONITORING SYSTEMS	<ul style="list-style-type: none"> - Two stream flow gages (located on the main) and northwest branches of Perkiomen Creek) are used to monitor flows entering the reservoir. - Rainfall gage located on north side of dam.
MODIFICATIONS	None recorded.
HIGH POOL RECORDS	<p>Reservoir water surface elevation records are maintained by the owner. The maximum reservoir surface elevation recorded is elevation 290.05 during Tropical Storm Agnes, June 1972. The period of record is from 1957.</p>
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	<p>The dam was last inspected in 1973, the firm engaged for the inspection was Woodward, Gardner and Associates.</p>
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None recorded.
MAINTENANCE OPERATION RECORDS	Maintenance/operation records are maintained by the owner.

ITEM	REMARKS
<div> <div>SPILLWAY PLAN</div> <div> <div>SECTIONS</div> <div>DETAILS</div> </div> </div>	<div>Refer to Appendix E.</div>
<div>OPERATING EQUIPMENT PLANS & DETAILS</div>	<div>Refer to Appendix E.</div>
<div>MISCELLANEOUS</div>	

APPENDIX

B

Check List

Visual Inspection

Phase I

CHECK LIST
VISUAL INSPECTION
PHASE I

Sheet 1 of 11

Name Dam Green Lane Reservoir Dam County Montgomery State Pennsylvania National ID # PA00618
Type of Dam Concrete Gravity Hazard Category High Hazard
Date(s) Inspection April 10, 1979 Weather Clear Temperature 400 F

Pool Elevation at Time of Inspection + 286.3 M.S.L. Tailwater at Time of Inspection + 221 M.S.L.

Inspection Personnel:

L.H. DeHeer
R.E. Horvath
R.R. Bowers
R.E. Horvath Recorder

Remarks:

The inspection team was accompanied by Mr. T.M. Kiely, Design Engineer, Philadelphia
Suburban Water Co. and Mr. D. King, Superintendent, Green Lane Reservoir Dam.

CONCRETE/MASONRY DAMS

Sheet 2 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	Seepage in the form of surface dampness was observed at a horizontal joint on the downstream face of the south non-over section.	The damp area should be inspected periodically to detect any significant change in flow quantity.
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	No deficiencies noted.	
DRAINS According to the drawing, no drains were constructed in the dam foundation.	A backfill drain located at the upstream end of south spray wall was discharging at the time of the inspection. A surface water drain subsurface drain located in the north spray wall were discharging at the time of the inspection.	The discharge appeared to be clear in all cases observed; flow quantities did not appear to be excessive.
WATER PASSAGES	Water passages were operational at the time of the inspection and therefore not inspected.	
FOUNDATION	Not inspected.	

CONCRETE/MASONRY DAMS

Sheet 3 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Refer to monolith joints below.	
STRUCTURAL CRACKING	None noted.	
VERTICAL AND HORIZONTAL ALIGNMENT	Vertical and horizontal alignment appear to be good.	
MONOLITH JOINTS	A crack in the vertical joint nearest the north abutment was noted. No differential alignment which might indicate movement was noted along the joint.	
CONSTRUCTION JOINTS	No deficiencies noted.	

EMBANKMENT

Sheet 4 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

SURFACE CRACKS

N/A

UNUSUAL MOVEMENT OR
CRACKING AT OR BEYOND
THE TOE

N/A

SLOUGHING OR EROSION OF
EMBANKMENT AND ABUTMENT
SLOPES

N/A

VERTICAL AND HORIZONTAL
ALIGNMENT OF THE CREST

N/A

RIPRAP FAILURES

The side slopes on the downstream side of the abutment are protected with riprap. No failures of the riprap or slope were noted.

EMBANKMENT

Sheet 5 of 11

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
------------------------------	---------------------	-----------------------------------

JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	N/A	
-------------------------------------------------------------	-----	--

ANY NOTICEABLE SEEPAGE	N/A	
------------------------	-----	--

STAFF GAGE AND RECORDER	N/A	
-------------------------	-----	--

DRAINS	N/A	
--------	-----	--

OUTLET WORKS

Sheet 6 of 11

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	None observed	
INTAKE STRUCTURE	The inlet structure was submerged at the time of the inspection. No abnormal conditions were noted.	
OUTLET STRUCTURE	The outlet structures were in operation at the time of the inspection.	
OUTLET CHANNEL	The outlet channel is the natural stream (Perkiomen Creek) bed. Deposits of sand and gravel were located about 200 feet downstream of the spillway.	
EMERGENCY GATE		N/A

UNGATED SPILLWAY

Sheet 7 of 11

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
CONCRETE WEIR	No deficiencies were noted. At the time of the inspection, the depth of flow over the spillway was about 0.3 feet.	
APPROACH CHANNEL	Not observed.	
DISCHARGE CHANNEL	Refer to outlet channel.	
BRIDGE AND PIERS	N/A	

GATED SPILLWAY

Sheet 8 of 11

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
CONCRETE SILL	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	

INSTRUMENTATION

Sheet 9 of 11

<u>VISUAL EXAMINATION</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
---------------------------	---------------------	-----------------------------------

MONUMENTATION/SURVEYS

N/A

OBSERVATION WELLS

N/A

WEIRS

Two stream flow recording stations are located on tributaries to the reservoir

PIEZOMETERS

N/A

OTHER

A raingage is located on the north abutment approximately 50' upstream from the dam axis. A reservoir stage recorder is activated by the static head on the 48-inch diameter blow off pipe.

RESERVOIR

Sheet 10 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

SLOPES

The slopes adjacent to the reservoir are relatively steep. They are, however, heavily wooded and are visually inspected on a daily basis.

SEDIMENTATION

Not determined.

DOWNSTREAM CHANNEL

Sheet 11 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

CONDITION
(OBSTRUCTIONS,
DEBRIS, ETC.)

A vehicular bridge and railroad bridge are located about 1,000 feet and 1,200 feet downstream of the dam respectively. Both appear to afford reasonable flow area.

SLOPES

The overbanks of Perkiomen Creek (downstream of the dam) are relatively flat and well vegetated.

APPROXIMATE NO.
OF HOMES AND
POPULATION

The borough of Green Lane is located within the damage center of the dam. The population of Green Lane is about 1,100.

APPENDIX

C

Hydrologic & Hydraulic Data

TABLE OF CONTENTS - APPENDIX C
HYDROLOGIC AND HYDRAULIC COMPUTATIONS

HYDROLOGY	SHEET 1
HYDRAULICS	SHEETS 2-3
HEC - I COMPUTER RESULTS	SHEETS 4-9



O'BRIEN & GERE

SUBJECT

GREEN LANE DAM

SHEET

1

BY

RRB
~~REK~~

DATE

3/23/79

JOB NO.

HYDROLOGY CALCULATIONS

DRAINAGE AREA: 71.0 mi.²

PMP CALCULATIONS (HMS REPORT 33)

AREA IS IN ZONE 6

24 HR., 200 SQ. MI. RAINFALL = 23"

HR.	%	RAINFALL	ΔRF
6	94	21.6"	21.6"
12	102	23.5"	1.9"
24	112	25.8"	2.3"
48	125	28.8"	3.0"

SNYDER COEFFICIENTS

FROM INFO. PROVIDED BY COE FOR THE
DELAWARE RIVER BASIN, ZONE 7 (SCHULYKILL RIVER
SUB-BASIN):

$$C_p = 0.65$$

$$\text{AND } C_t = 1.35$$

$$t_p = C_t (L \cdot L_{ca})^{0.3}$$

$$L = 13.8 \text{ miles}$$

$$L_{ca} = 8.7 \text{ miles}$$

$$t_p = 1.35 (13.8 \cdot 8.7)^{0.3} = 5.68 \text{ HRS.}$$

**O'BRIEN & GERE**

SUBJECT

GREEN LANE DAM

SHEET

2

BY

REB

DATE

JOB NO.

STAGE-STORAGE RATING CURVE (INFORMATION OBTAINED FROM PDER)

<u>ELEVATION</u>	<u>CAPACITY (10⁶ GAL.)</u>	<u>CAPACITY (A-FT)</u>
230	11	34
240	105	321
250	358	1096
260	806	2467
270	1563	4784
280	2989	9149
286	4377	13398
290	5535	16942
300 *	—	28610

* STAGE-STORAGE CURVE TERMINATED AT ELEVATION 290, USGS quad sheets were used to determine capacity for elevation 300.0

STAGE-DISCHARGE RATING CURVE (INFORMATION OBTAINED FROM PDER)

<u>ELEVATION</u>	<u>HEAD (FT)</u>	<u>DISCHARGE (CFS)</u>
286	0	0
287	1	1272
288	2	3777
289	3	7204
290	4	11,397
291	5	16,496
292	6	22,189
293	7	28,583
294	8	35,598
295	9	43,273
296	10	51,482
297	11	60,323
298	12	69,122

SUBJECT	SHEET	BY	DATE	JOB NO.
GREEN LAKE RESERVOIR DAM	3	REH	7/16/79	

For reservoir stages above elevation 297.0,
the parapet was assumed to be non-effective

— The effective weir length —

$$780 - 424 = 356' \quad \text{USE } L = 360'$$

— Assume $C = 3.1$

For stages above top of dam (elev 297.0),
additional discharge over the non-overflow
section $= 3.1(360)H^{3/2}$

.....
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 25 SEP 78

NATIONAL DAM INSPECTION PROGRAM	
GREEN LANE DAM	PHF HYDROGRAPH
1	A1
2	A2
3	A3
4	B
5	B1
6	J
7	J1
8	K
9	K1
10	M
11	P
12	T
13	W
14	X
15	X1
16	K1
17	Y
18	Y1
19	Y4
20	Y4
21	Y5
22	Y5
23	SS
24	SE
25	SS
26	SD
27	K

ROUTING THROUGH GREEN LANE RESERVOIR	
INFLUW	OUTFLO
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21
22	22
23	23
24	24
25	25
26	26
27	27

RUNOFF TO GREEN LANE RESERVOIR	
INFLUW	OUTFLO
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21
22	22
23	23
24	24
25	25
26	26
27	27

.....
 FLOOD HYDROGRAPH PACKAGE (NEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 25 SEP 78

RUN DATE 04/12/79.
 TIME 10:08:10.

NATIONAL DAM INSPECTION PROGRAM
 GREEN LANE DAM
 PMF HYDROGRAPH

JOB SPECIFICATION
 NO NHR NMN IDAY INR ININ METRC IPLT IPRT NSTAN
 300 1 0 0 0 0 0 0 -4 0
 JOBER NNT LROPT TRACE
 5 0 0 0 0

MULTI-PLAN ANALYSES TO BE PERFORMED
 NPLAN= 1 NRTIO= 9 LRTIO= 1

RTIOS= .20 .30 .40 .50 .60 .70 .80 .90 1.00

SUB-AREA RUNOFF COMPUTATION
 RUNOFF TO GREEN LANE RESERVOIR

ISTAO ICOMP IECON ITAPE JPLT JPRT INAME ISTAGE IAUTO
 INFLOW 0 0 0 0 0 0 1 0 0
 IHYDG IUMG TAREA SNAP TRSDA TRSPC RATIO ISNOW ISAME LOCAL
 1 1 71.00 0.00 0.00 71.00 0.00 0.000 0 1 0

PRECIP DATA

SPFE PMS R6 R12 R24 R48 R72 R96
 0.00 23.00 96.00 102.00 112.00 125.00 0.00 0.00

TRSPC COMPUTED BY THE PROGRAM IS .859

LOSS DATA

LROPT STGR DUTKR RTIOL ERAIN STRKS RTIOK STRTL CNSTL ALSMX RTIMP
 0 0.00 0.00 1.00 1.00 0.00 1.00 1.00 1.00 0.05 0.00 0.00

UNIT HYDROGRAPH DATA

TP= 5.68 CP= .65 NTA= 0

RECESSION DATA

STARTO= -1.50 ORCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 30 END-OF-PERIOD ORIGINATES, LAG= 5.68 HOURS, CP= .65 VOL= 1.00

359.	1319.	2572.	3873.	4954.	5272.	4992.	4213.	3426.	2787.
2266.	1893.	1499.	1219.	992.	806.	656.	533.	434.	353.
281.	243.	196.	154.	126.	102.	83.	68.	55.	45.

END-OF-PERIOD FLOW

MO.DA HR.MM PERIOD RAIN EXCS LOSS COMP 0

SUM 24.69 22.19 2.50 1060099.
(627.11 564.11 63.1130018.66)

.....

.....

.....

.....

.....

HYDROGRAPH ROUTING

ROUTING THROUGH GREEN LANE RESERVOIR

ISTAG ICOMP IECON ITAPE JPLT JPRT INAME ISTAGE IAUTO
OUTFLOW 0 0 0 0 0 0 0

ROUTING DATA
GROSS CLOSS AVG IRES ISAME IOPT IPMP LSTR
0.0 0.000 0.00 1 1 0 0 0

MSTPS NSTDL LAG ANSKK X TSK STORA ISPRAT
0 0 0.000 0.000 0.000 -286. -1

STAGE 286.00 287.00 288.00 289.00 290.00 291.00 292.00 293.00 294.00 295.00

FLOW 0.00 2272.00 3777.00 7204.00 11397.00 16496.00 22189.00 28583.00 35598.00 43273.00

CAPACITY= 34. 321. 1096. 2467. 4784. 9149. 13398. 16942. 20616.

ELEVATION= 230. 240. 250. 260. 270. 280. 290. 300.

CREL SPWD COOV EXPV ELEV COOL CAREA EXPL
286.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

TOPEL COOD EXPD DAHVID
297.0 3.1 1.5 360.

PEAK OUTFLOW IS 14669. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 22222. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 30652. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 38769. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 47152. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 55568. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 64994. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 73284. AT TIME 46.00 HOURS

4

1

7

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO	RATIOS APPLIED TO FLOWS								
					1	2	3	4	5	6	7	8	9
					.20	.30	.40	.50	.60	.70	.80	.90	1.00
HYDROGRAPH AT INLEW		71.80	1	17846.	26769.	35692.	44615.	53539.	62462.	71385.	80308.	89231.	
		(182.89)		(505.135)	(758.02)	(1010.70)	(1263.37)	(1516.04)	(1768.72)	(2021.39)	(2274.06)	(2526.74)	
ROUTED TO OUIFLO		71.80	1	14469.	22222.	30452.	38769.	47152.	55568.	64004.	73204.	82406.	
		(182.89)		(409.17)	(629.24)	(862.31)	(1097.82)	(1335.19)	(1573.50)	(1814.95)	(2072.90)	(2333.49)	

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1.....

ELEVATION
STORAGE
OUTFLOW

INITIAL VALUE
286.00
13398.
0.

SPILLWAY CREST
286.00
13398.
0.

TOP OF DAM
297.00
25114.
60323.

RATIO OF PMF	MAXIMUM RESERVOIR V.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	290.60	0.00	17645.	14569.	0.00	47.00	0.00
.30	292.01	0.00	19283.	22222.	0.00	47.00	0.00
.40	293.27	0.00	20755.	30452.	0.00	47.00	0.00
.50	294.41	0.00	22094.	38769.	0.00	47.00	0.00
.60	295.47	0.00	23331.	47152.	0.00	47.00	0.00
.70	296.46	0.00	24486.	55568.	0.00	47.00	0.00
.80	297.38	.38	25555.	64094.	2.00	47.00	0.00
.90	298.20	1.20	26516.	73204.	4.00	46.00	0.00
1.00	298.99	1.99	27442.	82406.	6.00	46.00	0.00

APPENDIX

D

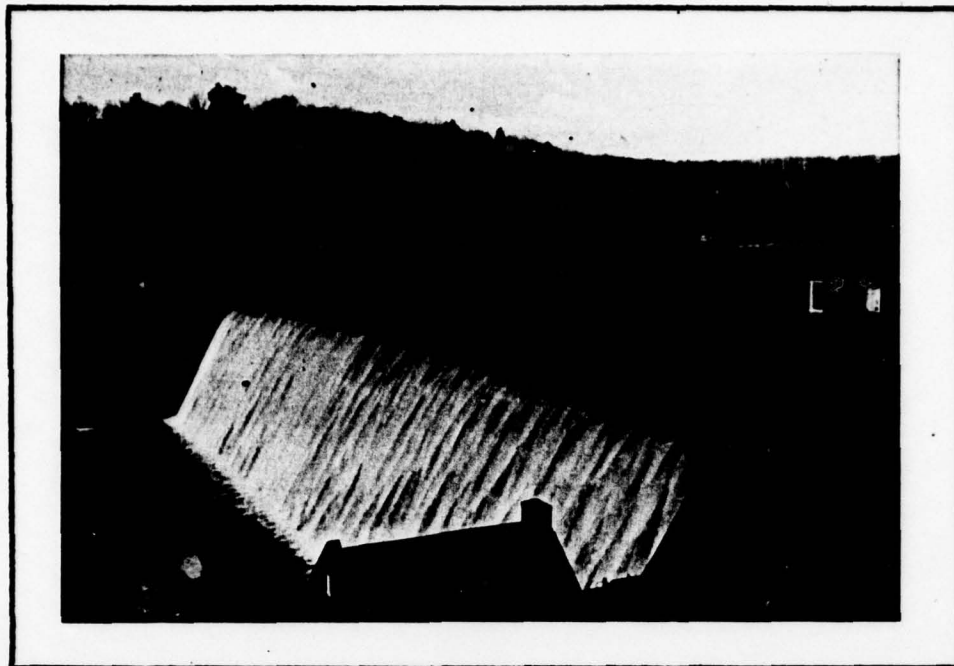
Photographs



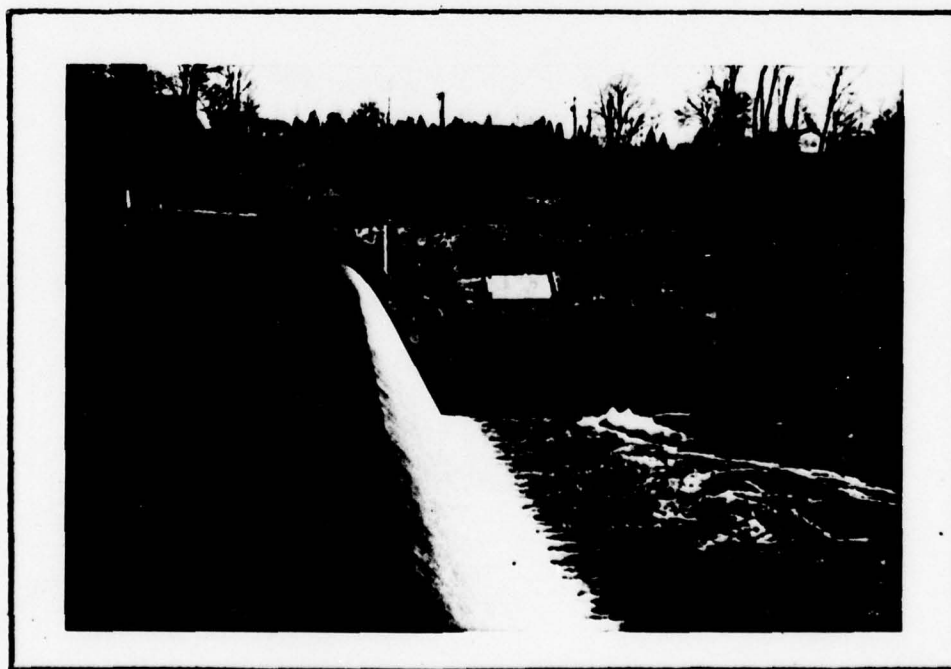
*INTAKE STRUCTURE AND THE UPSTREAM
SIDE OF THE OVERFLOW SPILLWAY*



*LOOKING UPSTREAM AT THE
OVERFLOW SPILLWAY*



*OVERFLOW SPILLWAY FROM THE LEFT
ABUTMENT LOOKING SOUTH*



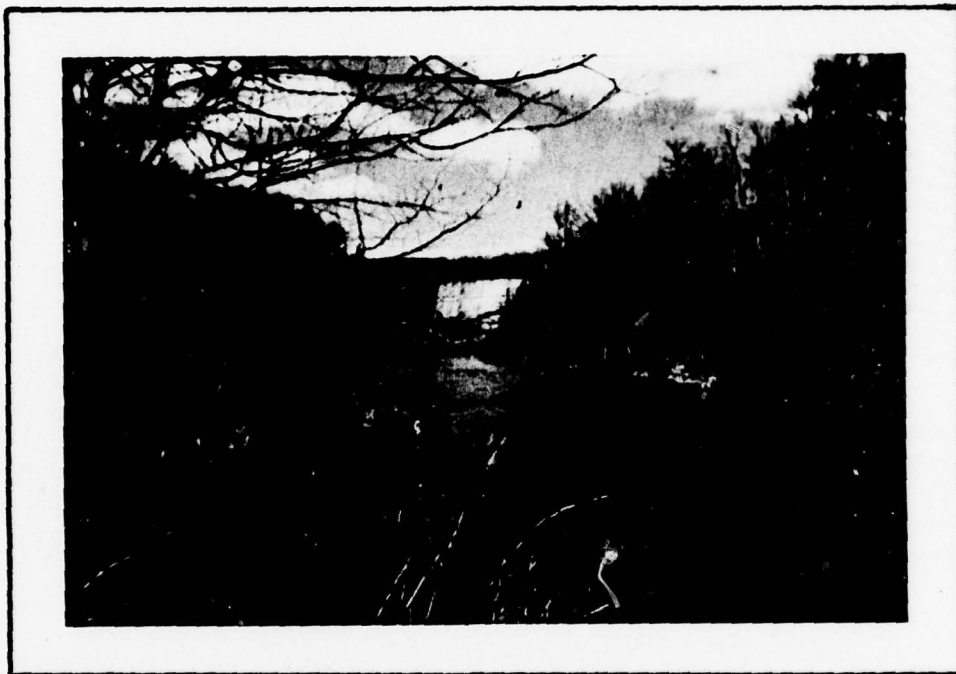
*OVERFLOW SPILLWAY AND GATEHOUSE
FROM THE RIGHT ABUTMENT LOOKING NORTH*



*PIPE OUTLETS IN NORTH SIDEWALL DOWNSTREAM
OF OVERFLOW SPILLWAY*



*OVERFLOW SPILLWAY OUTLET CHANNEL
SHOWING SAND AND GRAVEL DEPOSITS*



*DOWNSTREAM CHANNEL
WITH OVERFLOW SPILLWAY IN THE BACKGROUND*

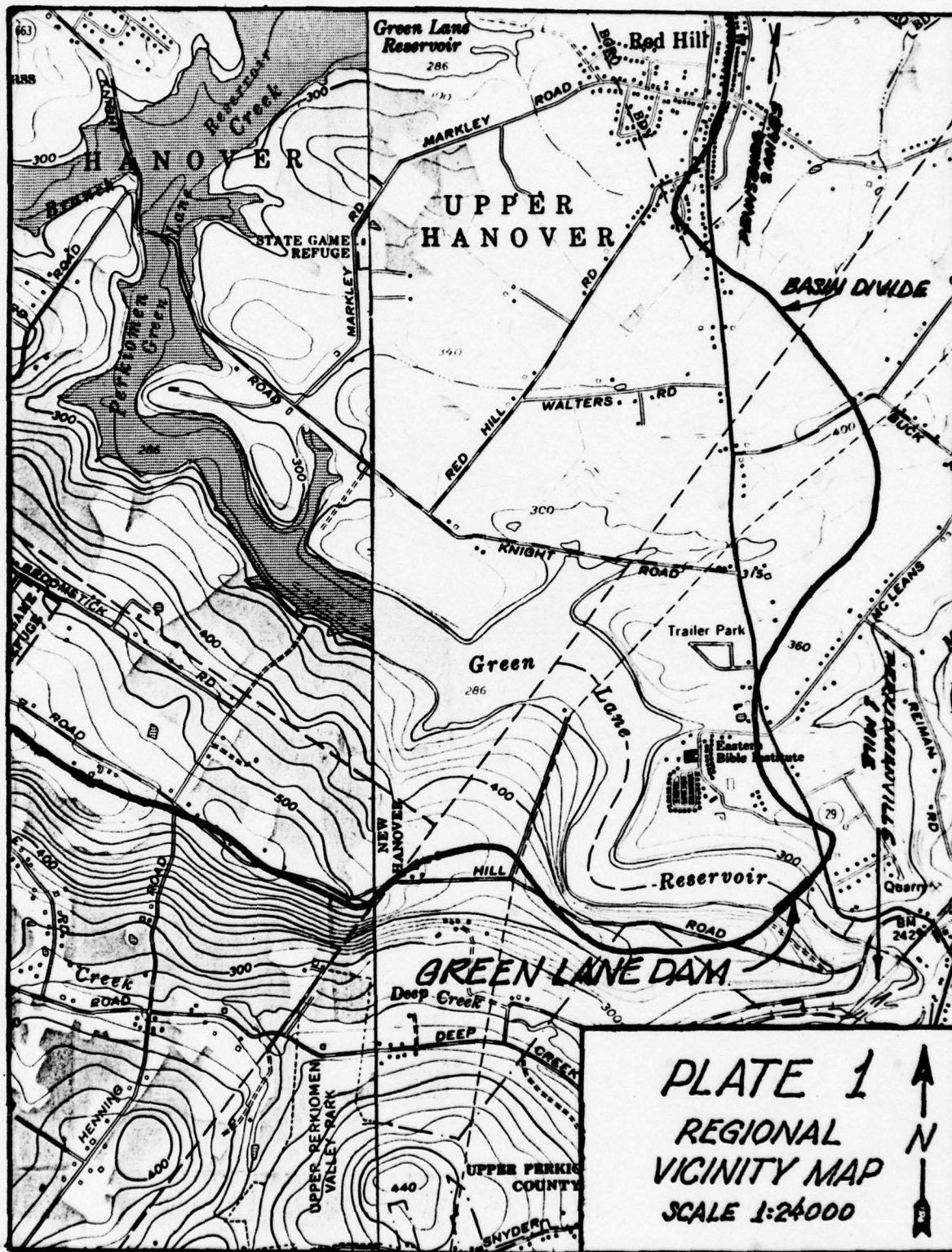
APPENDIX

E

Drawings

TABLE OF CONTENTS - APPENDIX E

REGIONAL VICINITY MAP	PLATE 1
DRAINAGE AREA AND LOCATION PLAN	" 2
PLAN OF DAM AND OUTLET CHANNEL	" 3
TYPICAL CROSS SECTIONS	" 4
PLAN AND PROFILE OF OUTLET WORKS	" 5
ELEVATION AND SECTION - OUTLET	" 6
PLAN AND SECTION OF OUTLET	" 7
PLANS AND SECTIONS CONTROL HOUSE-SUBSTRUCTURE	" 8
PLAN VIEW OF DAM WITH PROBLEMS NOTED	" 9





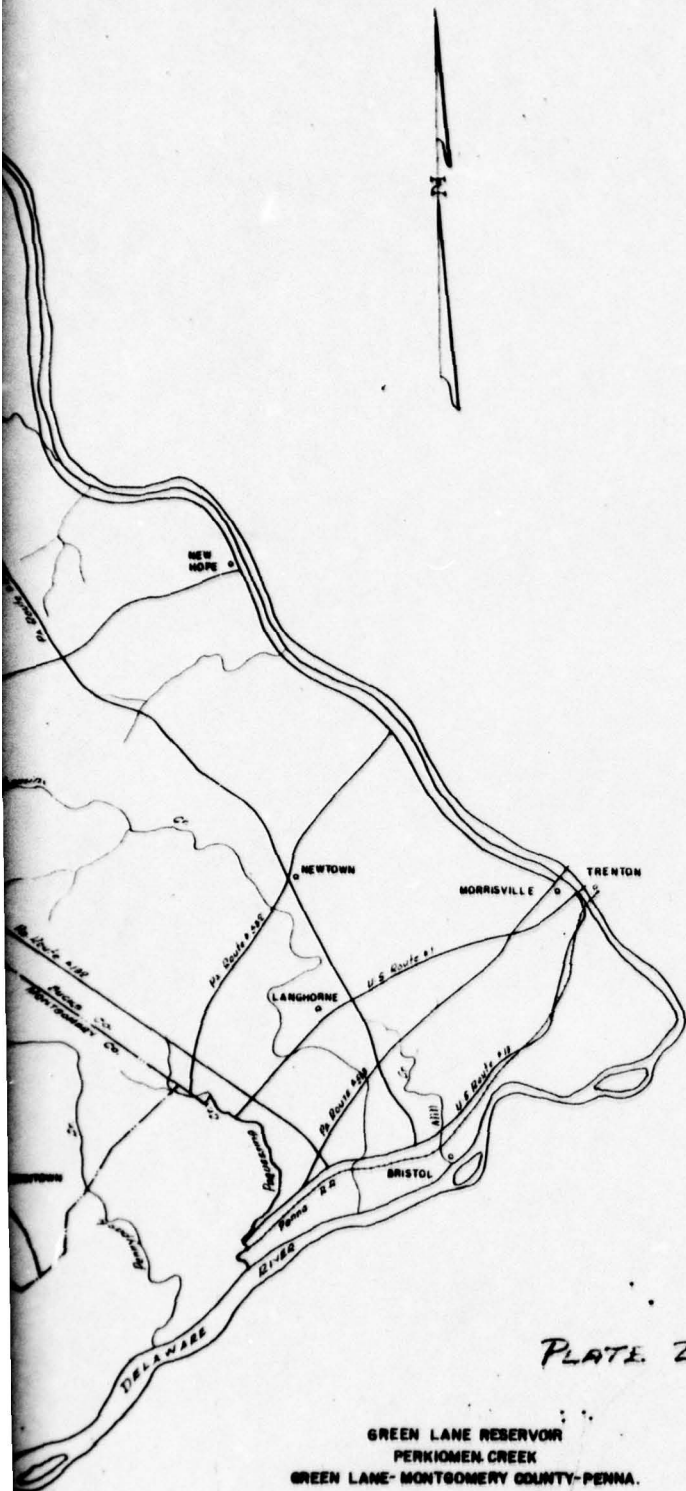


PLATE 2

GREEN LANE RESERVOIR
PERKIOMEN CREEK
GREEN LANE- MONTGOMERY COUNTY-PENNA.

DRAINAGE AREA AND LOCATION PLAN

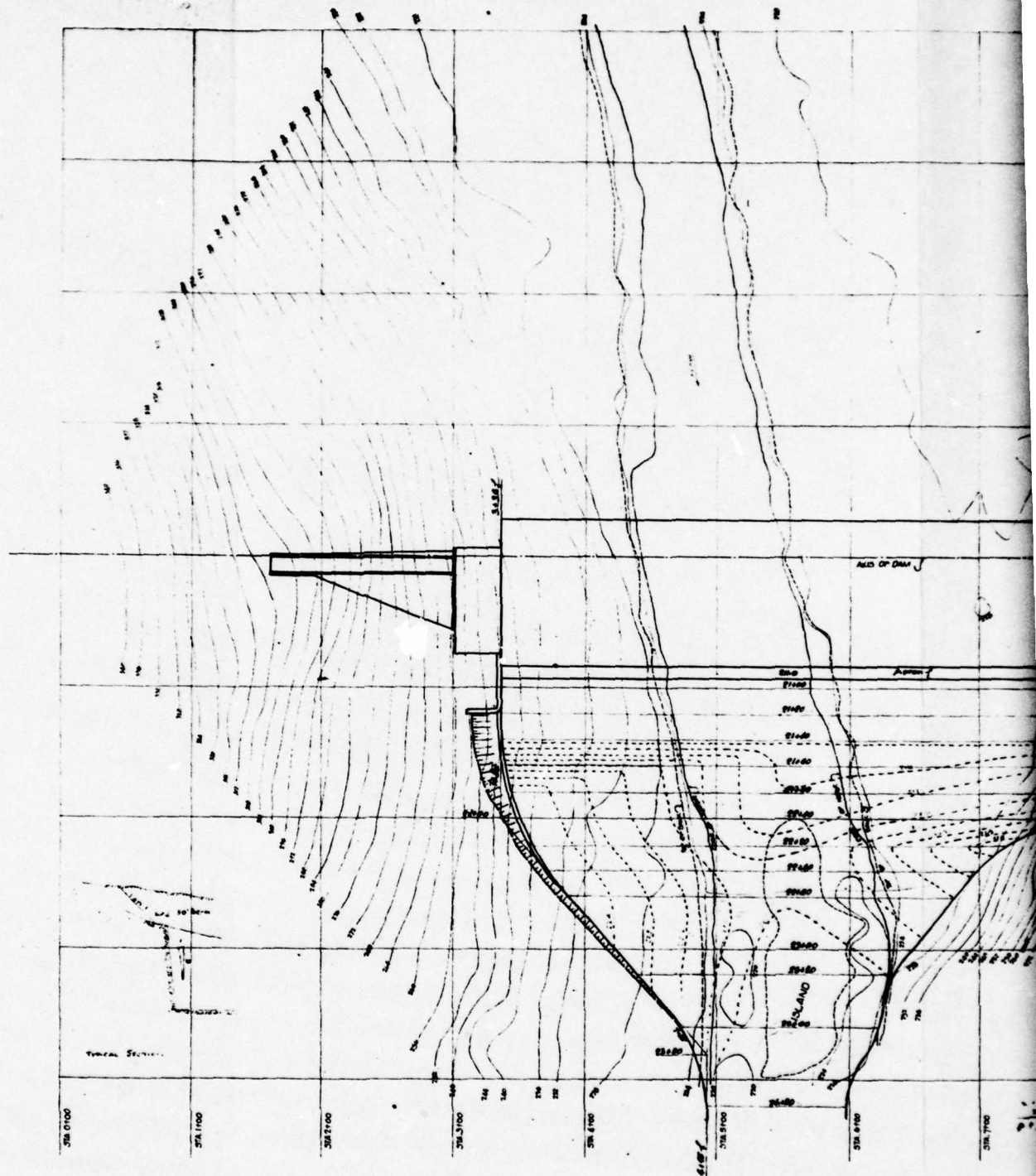
PHILADELPHIA SUBURBAN WATER COMMISSION
GRYNN MAWR, PA.



DATE: APRIL 15, 1938

SCALE: 1"=5000'

H. M. Freeman
By *H. M. Freeman*
Engineer & Surveyor
PHILADELPHIA



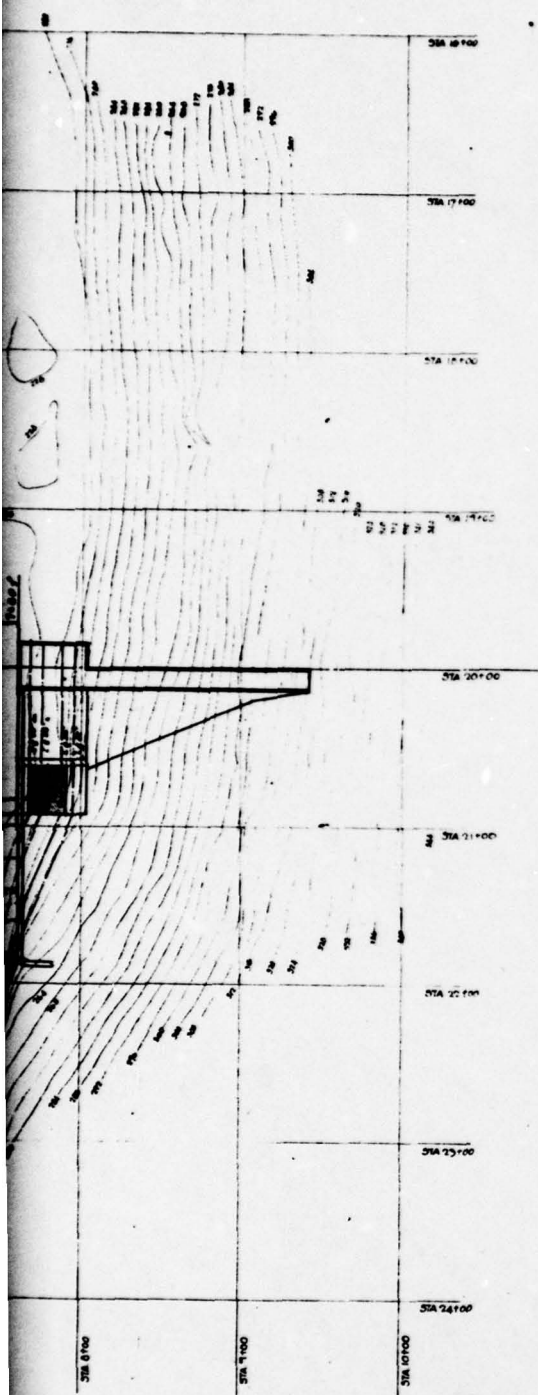


PLATE 3

GREEN LANE RESERVOIR
PERKIOMEN CREEK
GREEN LANE-MONTGOMERY COUNTY-PENNA.

PLAN OF DAM AND OUTLET CHANNEL

PHILADELPHIA SUBURBAN WATER COMPANY
BRYN MAWR, PA.

DATE: APRIL 15, 1932

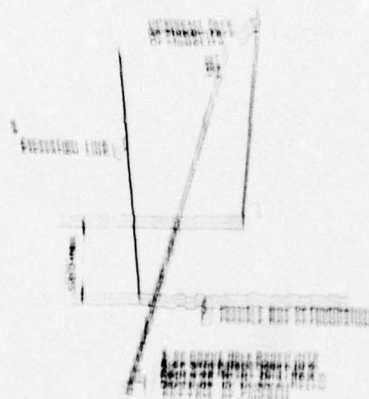
SCALE: 1" = 40 FT.

H. J. [Signature]
[Signature]
[Signature]
ALBANY & PAUL, ENGINEERS, PHILA., PA.

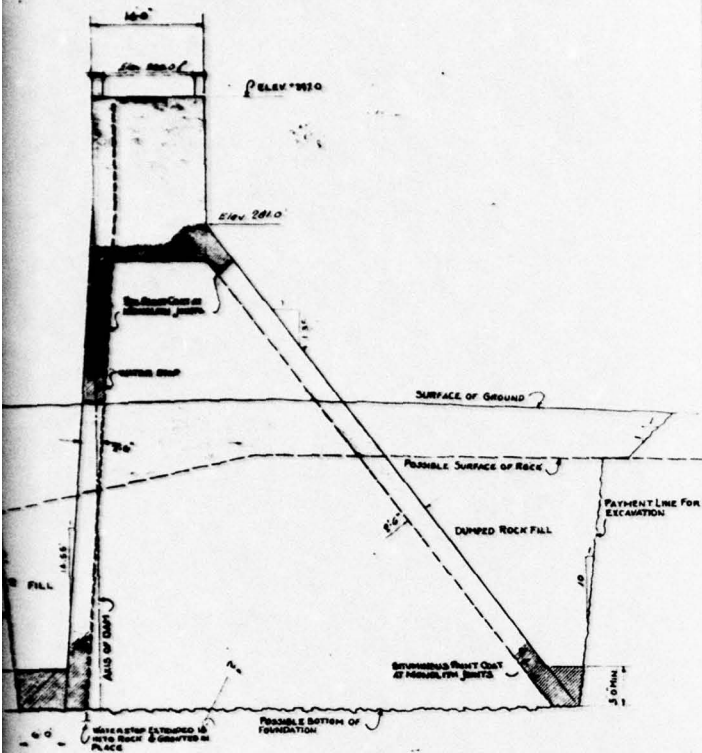
SEE 2-225 Sheet 29 of 30 sheets



CROSS-SECTION OF RAILWAY BED
 SCALE 1" = 10'



CROSS-SECTION OF RAILWAY BED
 SCALE 1" = 10'



DETAIL - NON OVERFLOW SECTION
SCALE 1/8"=1'-0"

PLATE 4

GREEN LANE RESERVOIR
PERKIOMEN CREEK
GREEN LANE-MONTGOMERY COUNTY-PENNA.

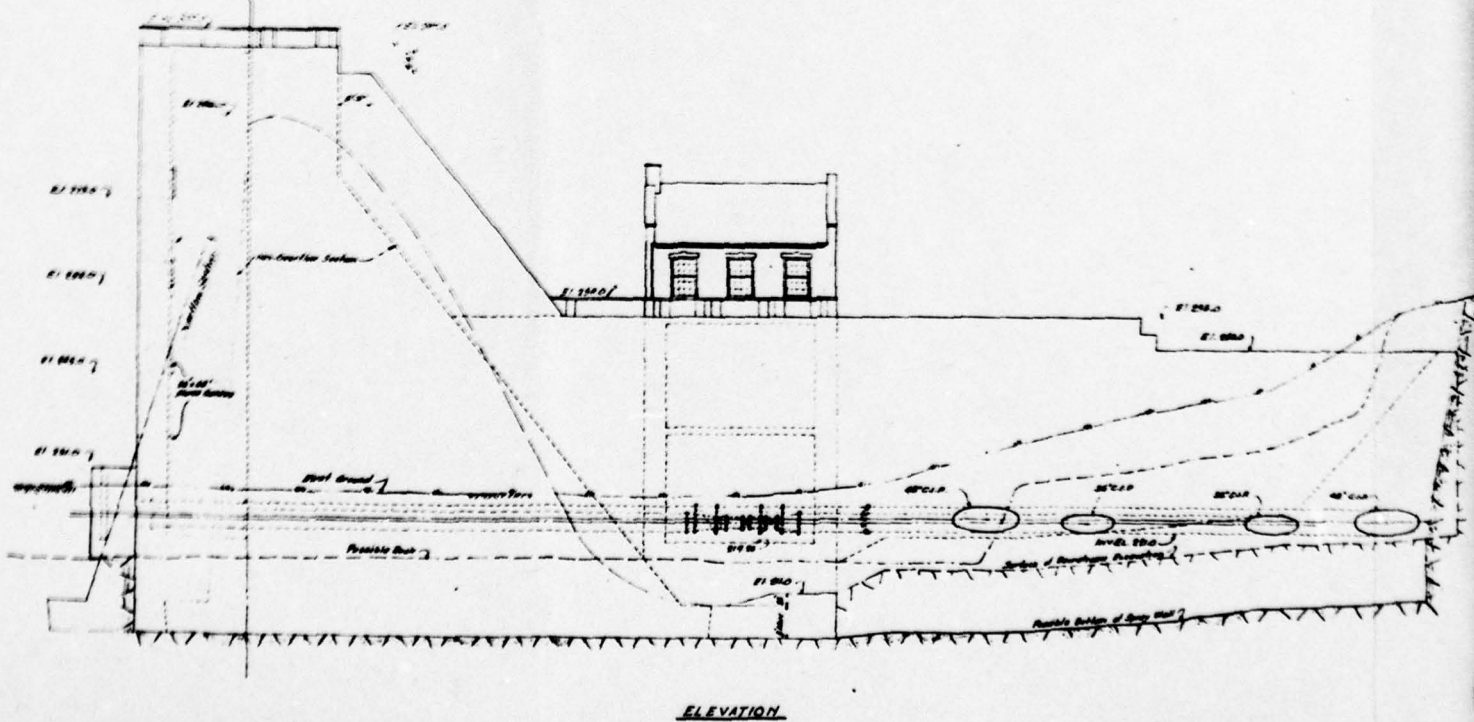
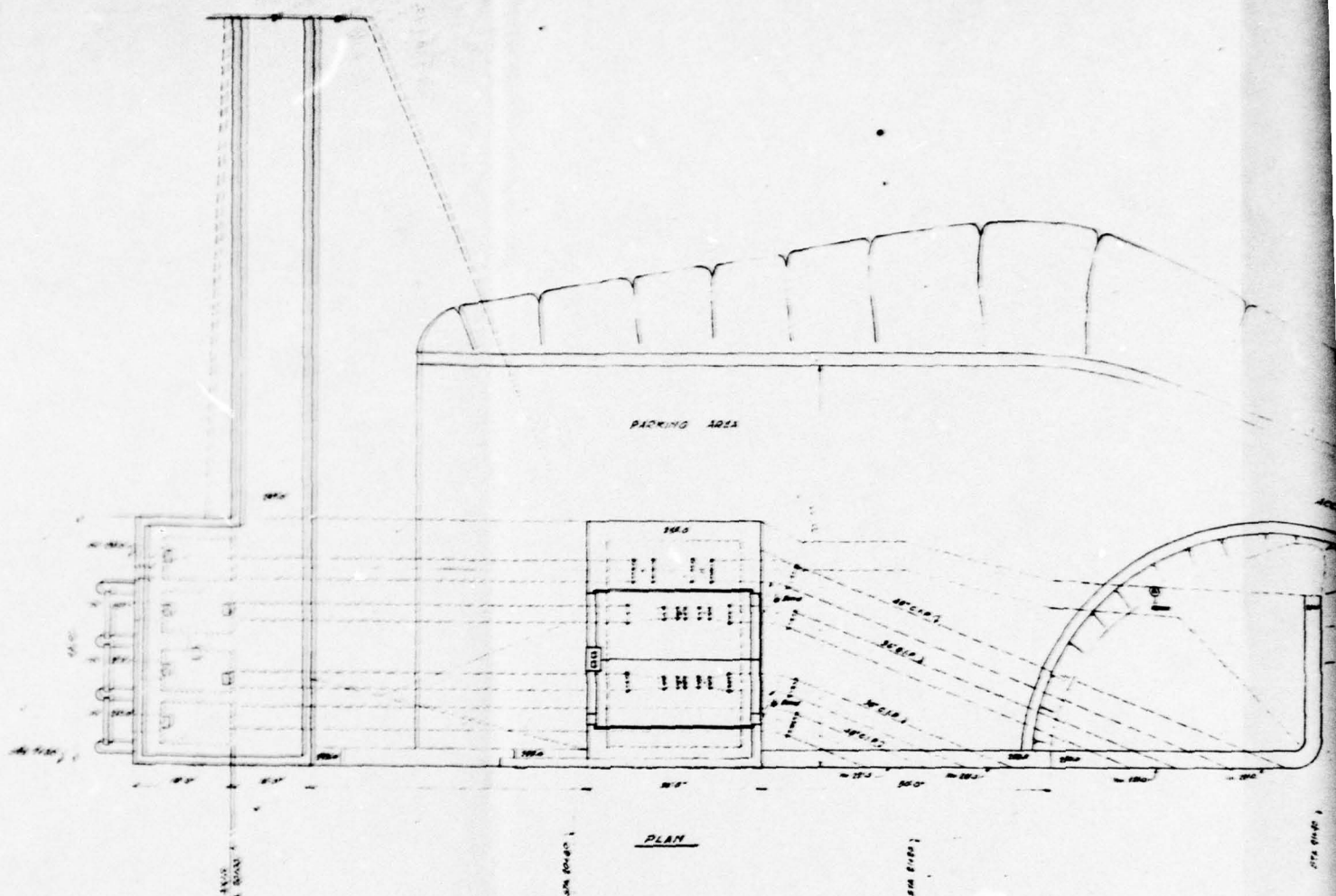
TYPICAL CROSS SECTIONS
PHILADELPHIA SUBURBAN WATER COMPANY
BRYN MAWR, PA.

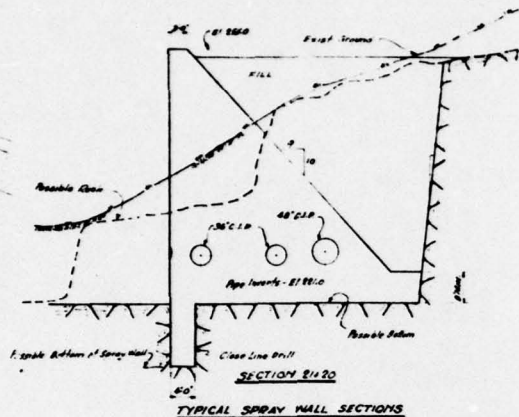
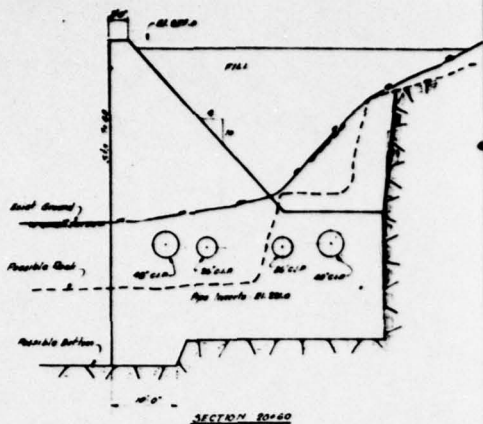
DATE: APRIL 15, 1932

SCALES AS NOTED

H. M. Freedman
H. M. FREEDMAN, CHIEF ENGINEER
Francis S. Friel
ALBRIGHT & FRIEL, CONSULTING ENGINEERS, PHILA. PA.







TYPICAL SPRAY WALL SECTIONS

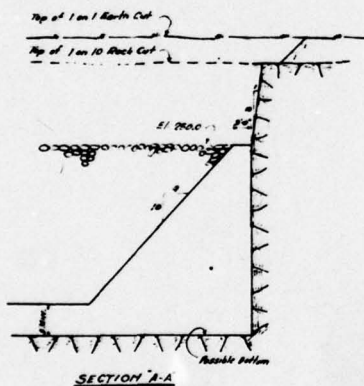


PLATE 5

GREEN LANE RESERVOIR
PERKIOMEN CREEK
GREEN LANE-MONTGOMERY COUNTY-PENNA.

PLAN AND PROFILE OF OUTLET WORKS

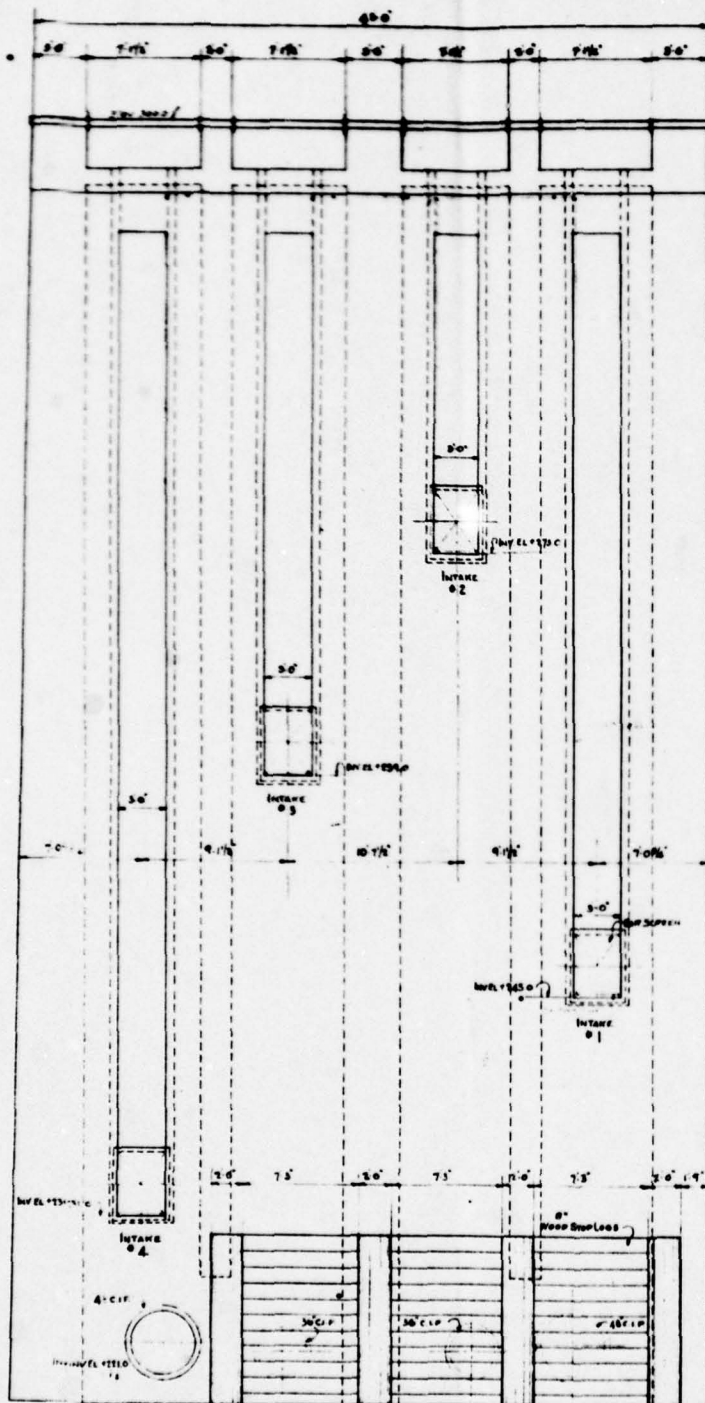
PHILADELPHIA SUBURBAN WATER COMPANY
BRYN MAWR, PA.

DATE: APRIL 10, 1952

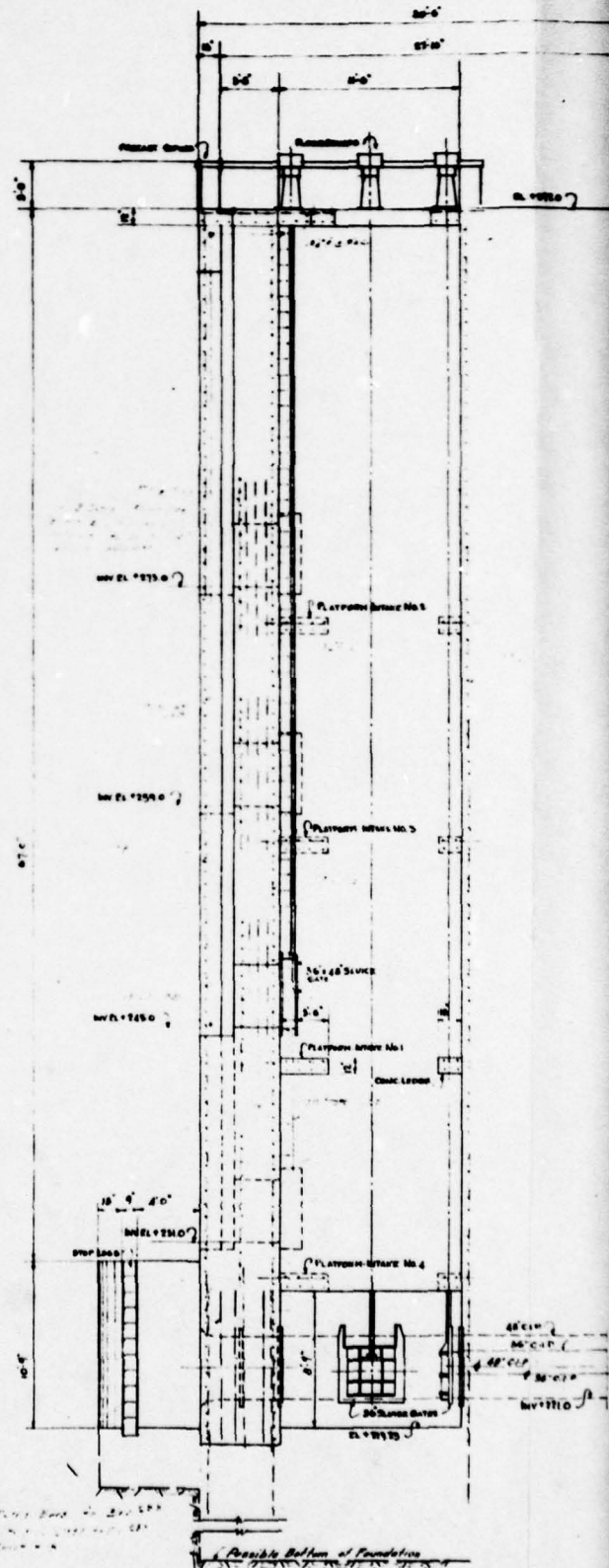
SCALE 1"=10 FT.

H. A. Friedman
H. A. FRIEDMAN, CIVIL ENGINEER
Francis A. Priel
ALDRICH & PRIEL, CONSULTING ENGINEERS, PHILA., PA.

2



ELEV. LOOKING DOWNSTREAM
SCALE 1/4" = 1'-0"



SECTION
SCALE 1/4" = 1'-0"

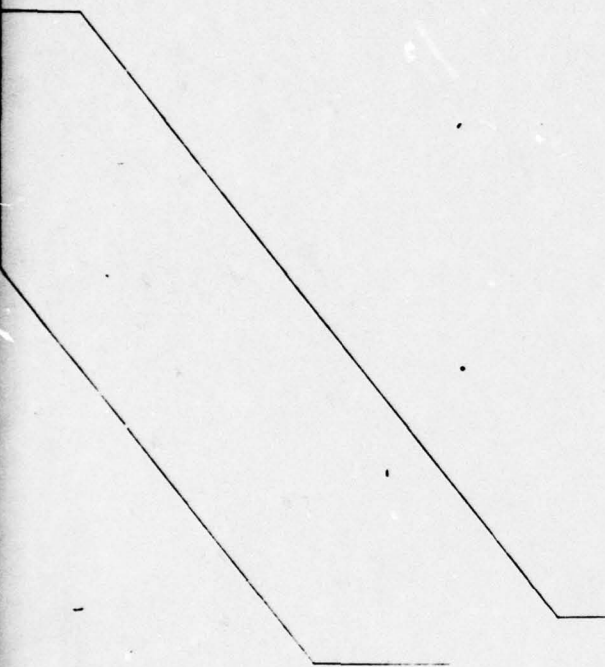


PLATE .C.

GREEN LANE RESERVOIR
PERKOWEN CREEK
GREEN LANE- MONTGOMERY COUNTY-PENNA.

ELEVATION AND SECTION-OUTLET

PHILADELPHIA SUBURBAN WATER COMPANY
BRYN MAWR, PA.

DATE: APRIL 15, 1922

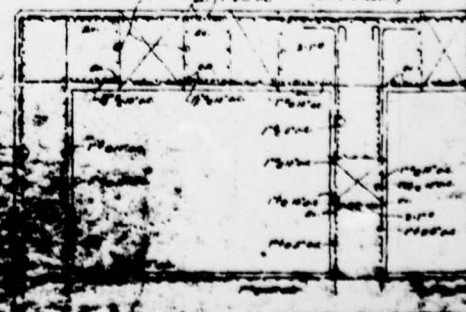
SCALE: AS NOTED

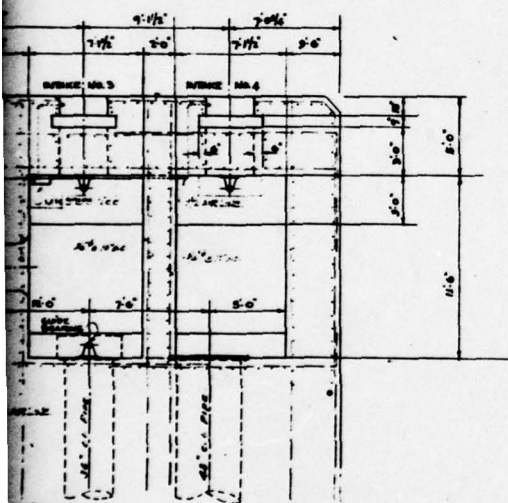
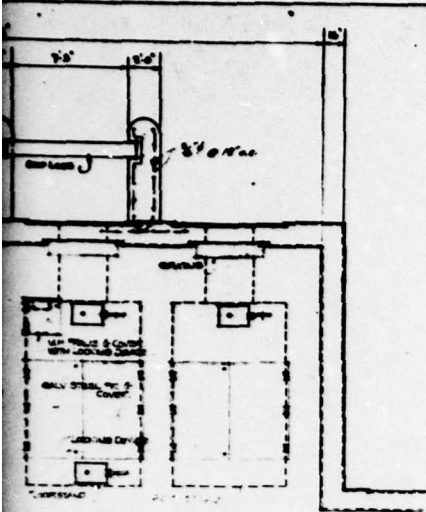
H. J. Fink

Francis J. Spill

ALBRIGHT & FINE, CONSULTING ENGINEERS, PHILADELPHIA, PA.

2





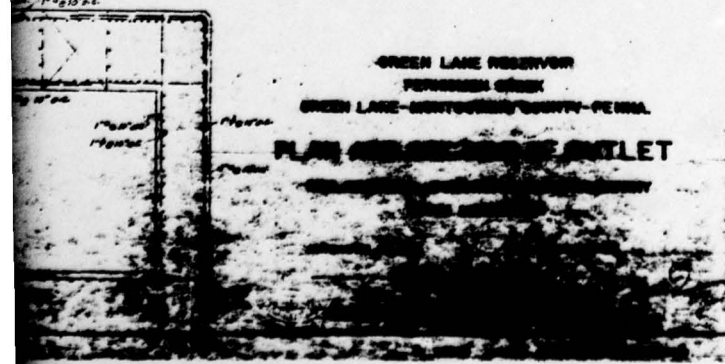
CONCRETE DESIGN CRITERIA

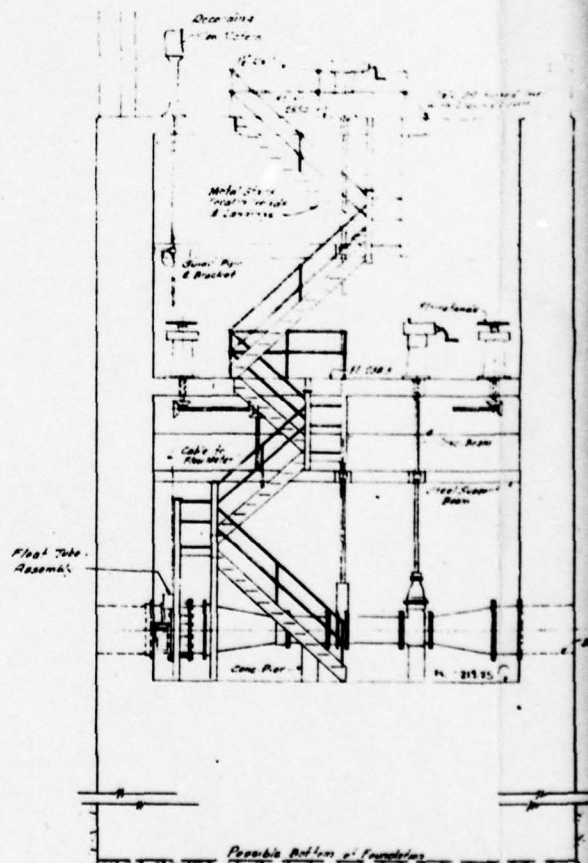
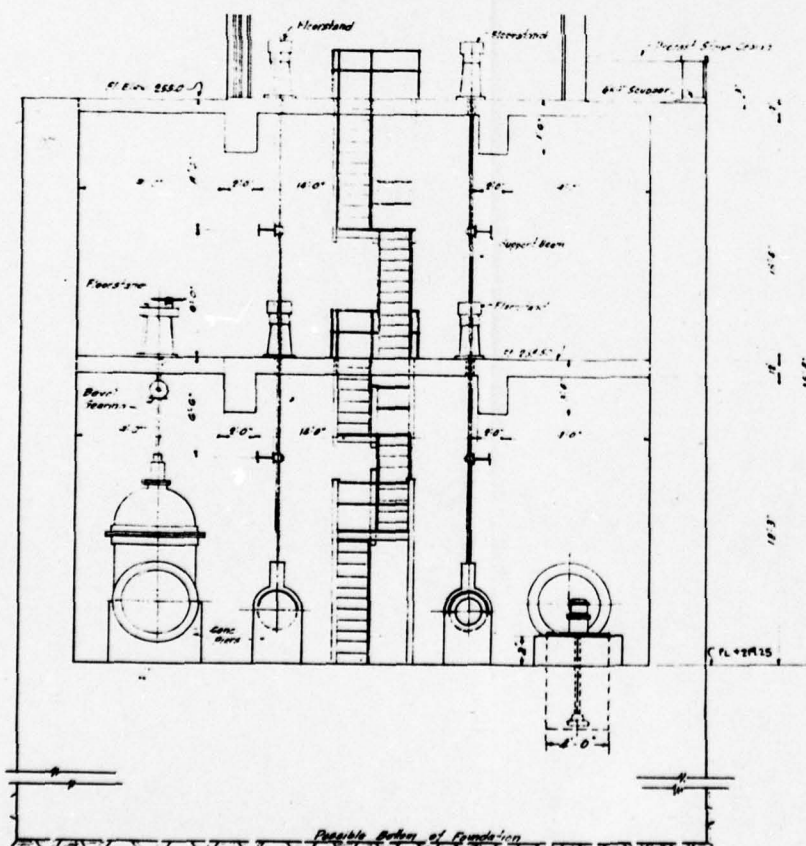
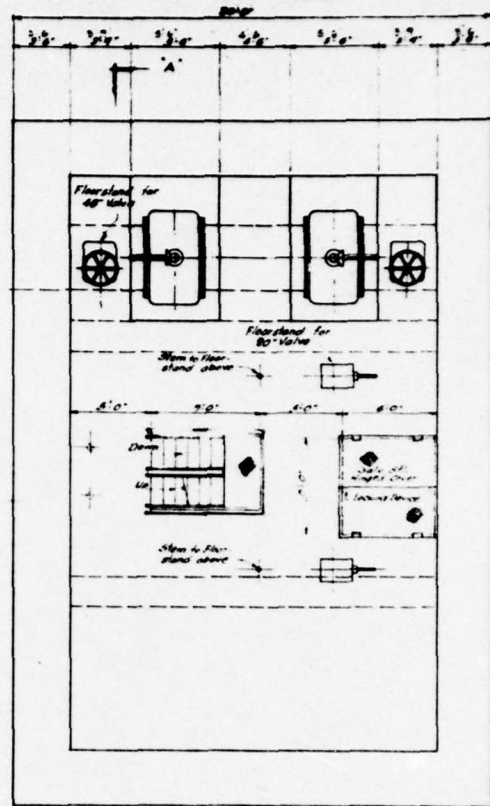
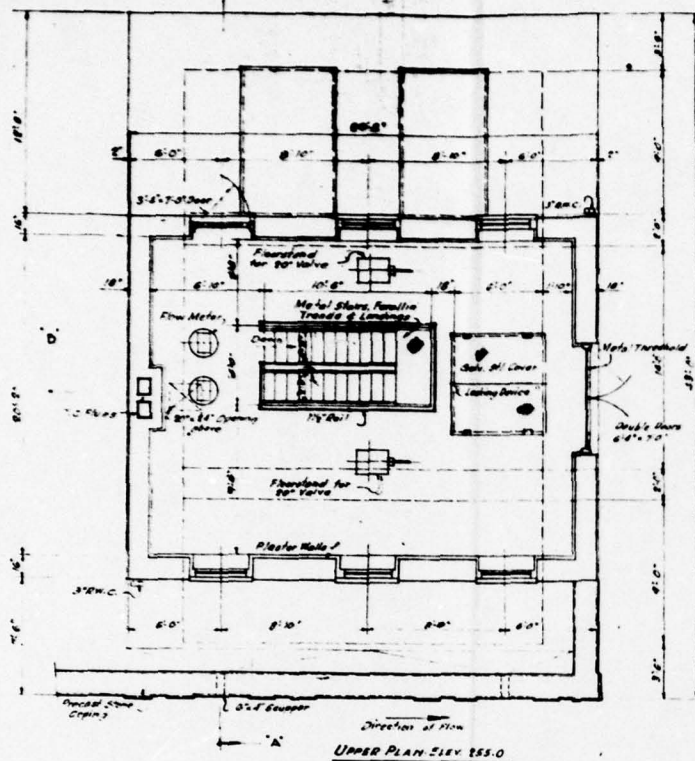
$f'_c = 3025 \text{ psi}$ $f'_c = 800 \text{ psi}$
 $f_y = 18,000 \text{ psi}$ Temp. 200°F A_c
 American Concrete Institute 318-81
 Minimum protection. Area of concrete
 to $\frac{1}{4}$ depth = 4"

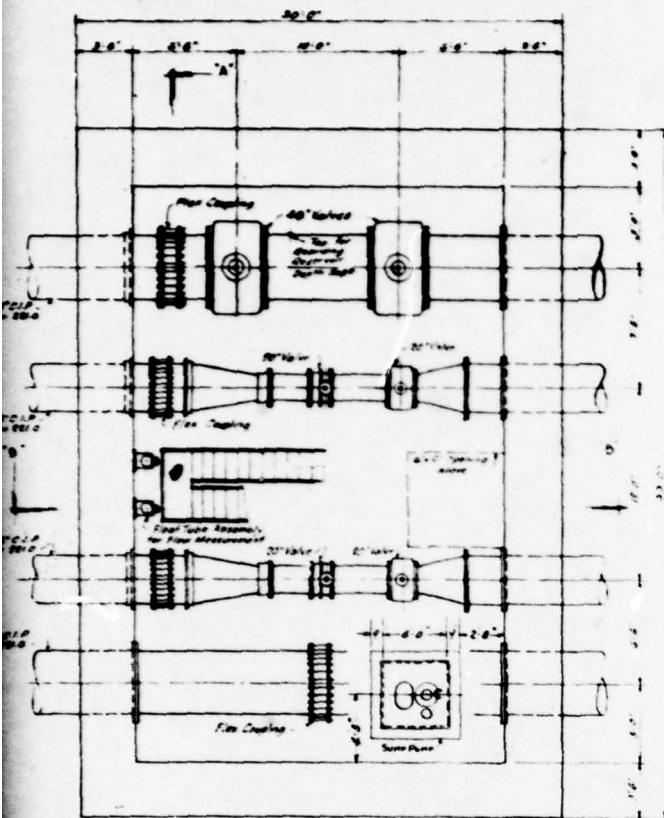
PLATE 7

GREEN LAKE RESERVOIR
 FERNHURST CREEK
 GREEN LAKE - MONTGOMERY COUNTY - PENNA.

PLAN AND SECTION OF OUTLET







— A — **LOWER PLAN ELEV 219 PS**

Note: Pipe closed to plan to 100 ft. run

Notes: 1. All pipes to be of galvanized steel, 2. All pipes to be of 1/2\"/>

PLATE E

GREEN LANE RESERVOIR
PERKIONE CREEK
GREEN LANE- MONTGOMERY COUNTY-PENNA.

PLANS AND SECTIONS CONTROL HOUSE-SUBSTRUCTURE

PHILADELPHIA SUBURBAN WATER COMPANY
BRYN MAWR, PA.



DATE: APRIL 15, 1932

SCALE 1"=4 FT.

H. J. Taylor
H. J. Taylor, Jr.
Francis J. Spick
Francis J. Spick
ELEMENTS & CIVIL ENGINEERING, PHILADELPHIA, PA.

GREEN LANE RESERVOIR DAM

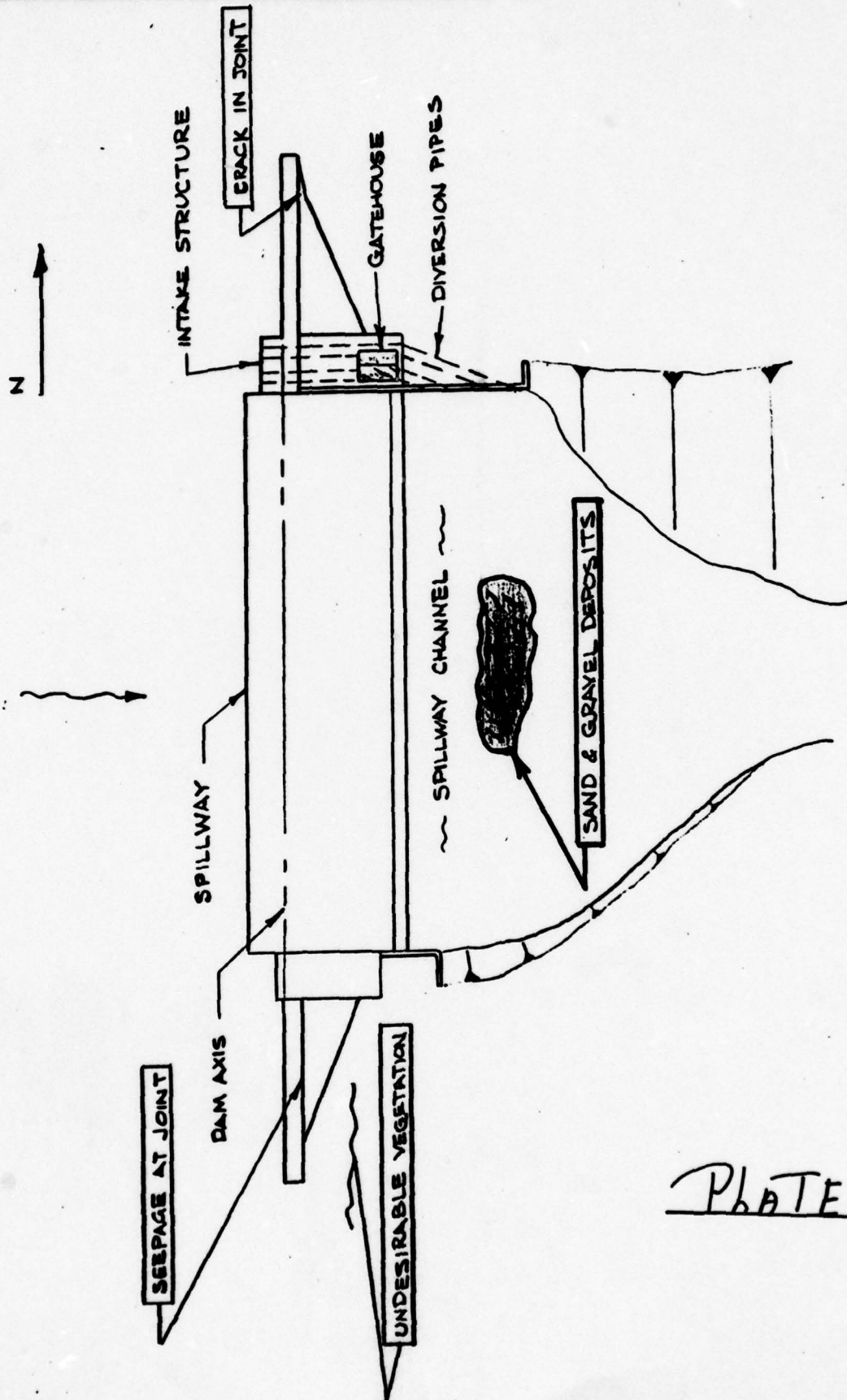


PLATE 9

APPENDIX

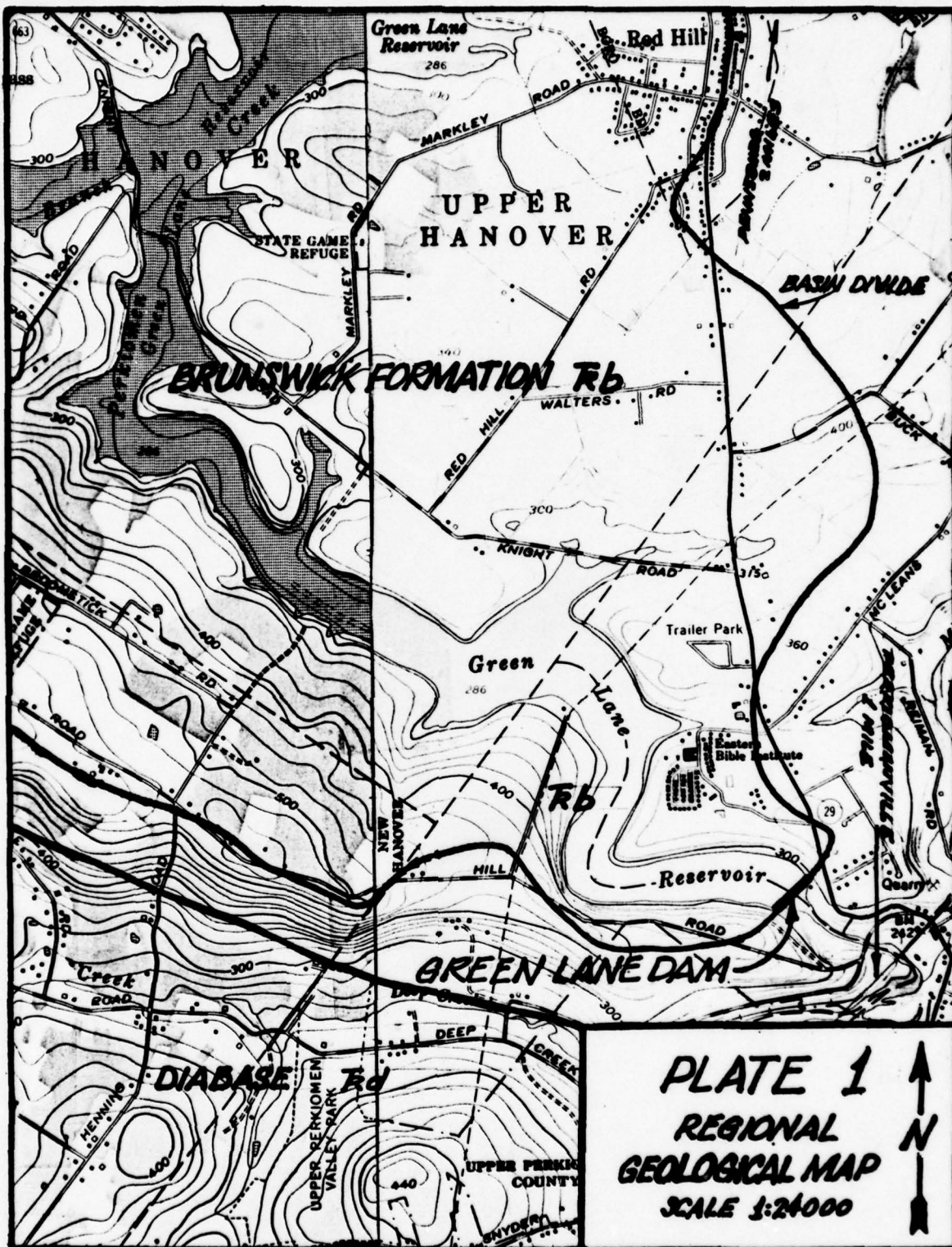
F

Site Geology

SITE GEOLOGY

GREEN LANE RESERVOIR DAM

The dam foundation is a metamorphosed bedrock considered to have been a red shale of the Triassic Brunswick formation. The shales have been "baked" by heat dissipation resulting from an igneous rock intrusion situated about 200 feet beneath the Perkiomen Creek Valley. The metamorphic process has recrystallized and hardened the shales such that the deleterious characteristics commonly associated with these rocks have been nearly destroyed. This formation contains two recognizable joint sets; one closely-spaced set trends NE-SW and the other extends in a NW-SE direction.



APPENDIX

G

Structural Stability Data

TABLE OF CONTENTS - APPENDIX G

STABILITY ANALYSES (PROVIDED BY PDER)

SHEETS 1-4

STABILITY ANALYSES (CURRENT CRITERIA)

SHEETS 5-17

PHILADELPHIA SUBURBAN WATER CO.
ENGINEERING DEPARTMENT

Page 1
Computed by B.T.H.
Date 4-7-52
Checked by S.A.R.T.

GREEN LANE DAM

CRITERIA NON OVERFLOW SECTION 3		
(1)	Freeboard below parapet wall	2.0'
(2)	Freeboard to top parapet wall	5.0'
(3)	Waves. F = 1 mi. V = 80 m.p.h.	
(4)	Test for Ice. 4500' per lin ft	
(5)	Resultant to fall at edge or within middle third.	
(6)	uplift factor 1.0 - Intensity factor 1.0	
(7)	No loads from back fill.	
(8)	Horizontal silt load on upstream face - Top silt 24000 - taken at equivalent liquid pressure 30' per cu ft	
(9)	Weight Concrete 150' per cu ft	
10	Coef. of friction joints	.75
11	Coef of friction foundation	.60
12	Shear in foundation 300' p.s.i.	
13	Shear friction factor to exceed 8	
14	Permissible foundation pressure	14000' s.f.

(15) Make Stability analysis of The dam based on the following conditions:

Case I Condition during maximum flood. with water elev. 295.

(Case II Reservoir full of water to El. 286. with ice. pressure.

Case III Reservoir Empty -



OBRIEN & GERE

SUBJECT

GREEN LANE RESERVOIR DAM

SHEET

2

BY

DATE

JOB NO

STABILITY ANALYSES - NON-OVERFLOW SECTION (INFORMATION PROVIDED BY PDER)

LOADING	RESULTANT LOCATION	SLIDING $\frac{\Sigma H_h}{\Sigma V F}$	BASE PRESSURES (PSF)
RESERVOIR EMPTY	49.22	N/A	1043 (7.2 psi) 13533 (93.9 psi)
NORMAL POOL	32.43	.6	7164 (49.8 psi)
with ICE LOAD (18" @ 4500 psf) (ELEV. 295.0)			2658 (18.5 psi)
MAXIMUM POOL	26.56	13 *	8968 (62.3 psi)
with TAILWATER			380 (2.6 psi)

— BASE WIDTH = 76.57'

— RESULTANT LOCATION - DISTANCE IN FEET FROM TOE OF DAM

Subject Green Lane Dam.CRITERIA FOR SPILLWAY DESIGN

- | | | |
|-----------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------|
| 1 Design discharge ... | 5000 \sqrt{A} | 42000 cfs |
| 2 Water shed area | | 71.9 mi |
| 3 Elevation of Spillway crest | | 206 |
| 4 Elevation of top of non overflow section | | 297 |
| 5 Elevation of top of Parapet wall | | 300 |
| 6 Length of overflow section of spillway | | 424 ft. |
| 7 "C" factors for spillway design -- in accordance with chart Fig. No 7, page 367 "Engineering for Dams" Hinds, Creager & Justin. | | |
| 8 Design head | | 9'-0" |
| 9 Free board to top of non-overflow section | | 2'-0" |
| 10 Free board to top of parapet wall. | | 5'-0" |
| 11 The resultant line of all loads shall fall at edge of or within the middle third of the base of the dam. | | |
| 12 Permissible foundation pressure | | 14000 lb./sf. |
| 13 Uplift factor 1.0 on 100% of base | | |
| 14 weight of concrete 150 lbs. per cu ft | | |
| 15 Test Ice Pressure | | |
| 16 Do not use any loads from back fill in design (not presently anticipated) | | |
| 17 Sedimentation load 30 lbs per cu ft. for a height of 20 feet above present creek bed | | |
| 18 Maximum Reservoir elevation | | 295 |
| 19. Coef. of friction on foundation (f) | | .6 |
| Coef. of friction on joints (f) | | .75 |



OBRIEN & GERE

SUBJECT

GREEN LANE RESERVOIR DAM

SHEET

4

BY

DATE

JOB NO

STABILITY ANALYSES — SPILLWAY SECTION (INFORMATION
PROVIDED BY PDER)

LOADING	RESULTANT LOCATION	SLIDING $\frac{\sum H_F}{\sum V_F}$	BASE PRESSURES (psf)
RESERVOIR EMPTY	46.72	N/A	5676 (39.4 psi) 8746 (60.7 psi)
NORMAL POOL	33.68	.49	8409 (58.4 psi) 1558 (10.8 psi)
(ELEV. 295.0) MAXIMUM POOL with TAILWATER	29.69	.57	8634 (59.9 psi) 184 (1.3 psi)
(ELEV. 295.0) MAXIMUM POOL with HYDRAULIC JUMP	29.30	.60	9609 (66.7 psi) 72 (.5 psi)

— BASE WIDTH = 87.25

— RESULTANT LOCATION — DISTANCE IN FEET FROM TOE
OF DAM



SUBJECT

GREEN LANE RESERVOIR DAM

SHEET

5

BY

REH

DATE

JOB NO.

STABILITY ANALYSES

- ASSUMPTIONS

Concrete Density - 150 pcf

Silt Density - 86 pcf

Silt Depth - 20 ft.

Active Earth Pressure Coeff - 0.33

Tailwater Elevation - 240.0

Shear stress - 50 psi

Ice Pressure - 5,000 psf

Earthquake Acceleration - 0.025g

(Seismic Zone 1)

Coeff. of Friction - 0.6

No keyway is constructed, passive earth
resistance is not considered



OBRIEN & GERE

SUBJECT

GREEN LANE RESERVOIR DAM

SHEET

6

BY

DATE

JOB NO

STABILITY ANALYSES — SPILLWAY SECTION

LOADING	RESULTANT LOCATION	OVERTURNING SAFETY FACTOR	BASE PRESSURES (PSI)	SLIDING SAFETY FACTOR
NORMAL POOL	34.36	1.87	61.73 13.61	4.23
PMF w/HYDRAU. JUMP	26.20	1.49	76.66 - 6.95	3.16
PMF w/ TAILWATER	26.34	1.35	60.39 - 5.23	3.46
NORMAL POOL w/ ICE LOADING	35.78	1.93	58.37 17.40	4.45
NORMAL POOL w/ EARTHQUAKE	32.96	1.80	65.33 10.01	3.85

- BASE WIDTH = 87.3 FEET

- RESULTANT LOCATION - DIST. IN FEET FROM TOE OF DAM

- NEGATIVE BASE PRESSURES RESULT FOR LOADINGS

WHEN THE RESULTANT OF FORCES IS LOCATED OUTSIDE
THE MIDDLE THIRD OF BASE WIDTH



SUBJECT

GREEN LAKE RESERVOIR DAM

SHEET

7

BY

DATE

JOB NO.

STABILITY ANALYSES — NON-OVERFLOW SECTION

LOADING	RESULTANT LOCATION	OVERTURNING SAFETY FACTOR	BASE PRESSURES (PSI)	SLIDING SAFETY FACTOR
NORMAL POOL	33.91	1.81	45.83	3.59
			22.49	
PMF w/ TAILWATER	24.95	1.29	48.77	2.87
			-0.91	
NORMAL POOL w/ICE LOADING	34.89	1.83	42.91	3.68
			25.40	
NORMAL POOL w/EARTHQUAKE	32.09	1.74	50.44	3.63
			17.87	

— BASE WIDTH = 76.3 FEET

— RESULTANT LOCATION - DIST. IN FEET FROM TOE OF DAM



O'BRIEN & GERE

SUBJECT

GREEN LANE RESERVOIR DAM

SHEET

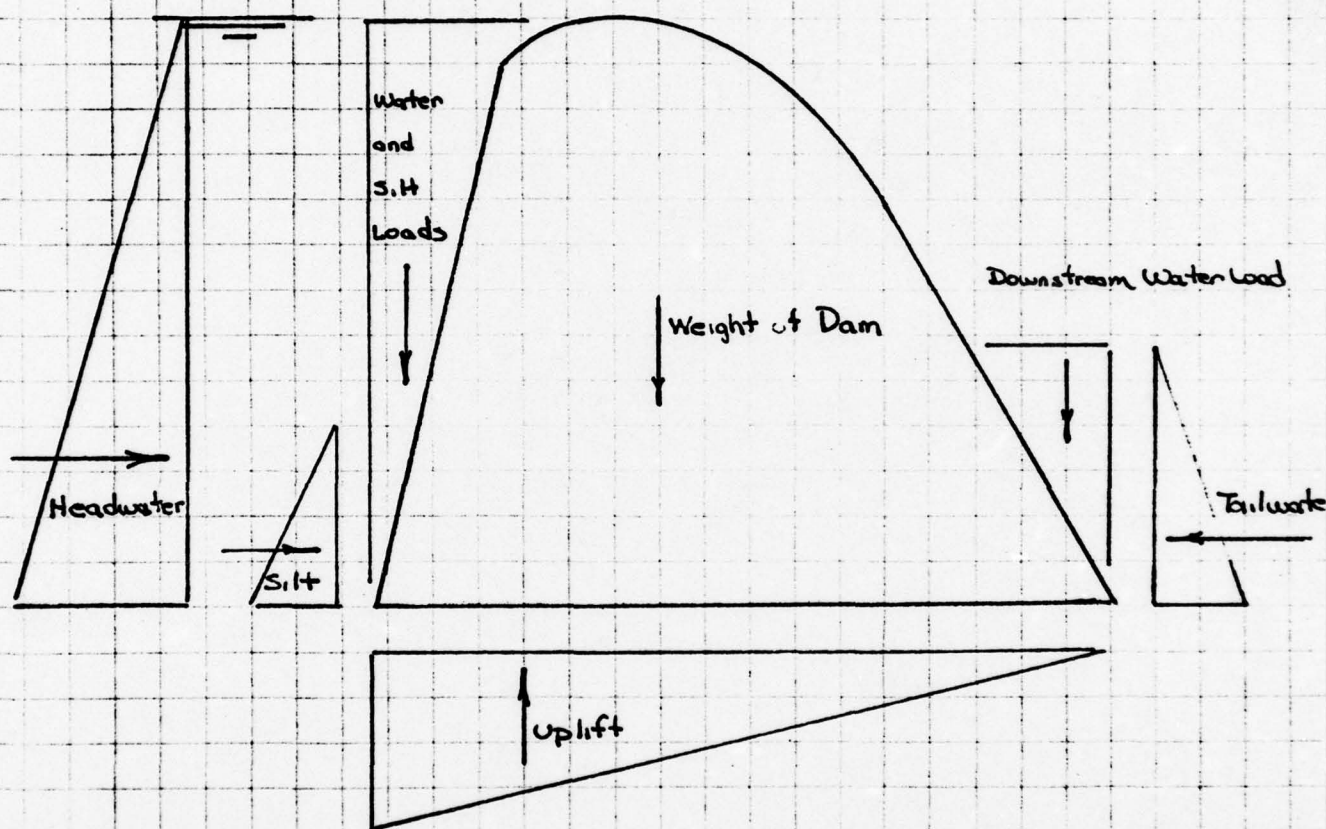
8

BY

DATE

JOB NO

STABILITY ANALYSES - GENERAL LOADING DIAGRAM



 GREEN LANE RESERVOIR DAM SPILLWAY SECTION
 NORMAL POOL USE = 286

 BASE ELEVATION= 204.00FT. TOP ELEVATION= 286.00FT. BASE WIDTH= 87.30FT. DENSITY= 150.00PCF
 HEADWATER ELEVATION= 286.00FT. TAILWATER ELEVATION= 204.00FT. EARTHQUAKE ACCELERATION= 0.000G (HORIZ) 0.000G (VERT)
 SILT ELEVATION= 224.00FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 87.30FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(Feet)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	621.39	46.72	29076.88	
HEADWATER	209.79	27.31		5728.48
UPLIFT	223.35	58.20		12998.86
SILT	5.73	6.67		38.18
WATER LOAD	69.80	78.40	5472.32	
SILT LOAD	5.70	85.10	485.07	
			*****	*****
			35034.26	18765.53

 NET HORIZONTAL FORCE= 215.52 KIPS
 NET VERTICAL FORCE= 473.54 KIPS
 NET MOMENT= 16268.73 KIP-Feet
 X-BAR OF FOUNDATION REACTION= 34.36 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 9.29 FEET
 FOUNDATION REACTION PRESSURES*****TOE= 61.73 PSI*****HEEL= 13.61 PSI*****
 OVERTURNING FACTOR OF SAFETY= 1.87
 SLIDING FACTOR OF SAFETY= 1.32
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .46
 SLIDING WITH SHEAR FACTOR OF SAFETY= 4.23(SHEAR ACROSS FULL BASE WIDTH)

 GREEN LAKE RESERVOIR DAM SPILLWAY SECTION
 PMF WITH HYDRAULIC JUMP

 BASE ELEVATION= 204.00FT. TOP ELEVATION= 286.00FT. BASE WIDTH= 87.30FT. DENSITY= 150.00PCF
 HEADWATER ELEVATION= 298.99FT. TAILWATER ELEVATION= 204.00FT. EARTHQUAKE ACCELERATION= .000G (HORIZ), .000G (VERT)
 SILT ELEVATION= 224.00FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 87.30FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(Feet)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	621.39	46.79	29076.88	8459.37
HEADWATER	276.26	30.62		15058.05
UPLIFT	258.73	58.20		38.18
SILT	5.73	6.67		
WATER LOAD	69.80	78.40	5472.32	
SILT LOAD	5.70	95.10	485.07	
			*****	*****
			35034.26	23555.61

NET HORIZONTAL FORCE= 281.98 KIPS
 NET VERTICAL FORCE= 438.16 KIPS
 NET MOMENT= 11478.45KIP-Feet
 X-BAR OF FOUNDATION REACTION= 26.20 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 17.45 FEET
 *****FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE*****TENSION AT HEEL OF DAM*****
 FOUNDATION REACTION PRESSURES*****TOE= 76.66 PSI*****HEEL= -6.95 PSI*****
 OVERTURNING FACTOR OF SAFETY= 1.49
 SLIDING FACTOR OF SAFETY= .93
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .64
 SLIDING WITH SHEAR FACTOR OF SAFETY= 3.16(SHEAR ACROSS FULL BASE WIDTH)

 GREEN LANE RESERVOIR DAM SPILLWAY SECTION
 PMF WITH TAILWATER

 BASE ELEVATION= 204.00FT. TOP ELEVATION= 286.00FT. BASE WIDTH= 87.30FT. DENSITY= 150.00PCF
 HEADWATER ELEVATION= 298.99FT. TAILWATER ELEVATION= 240.00FT. EARTHQUAKE ACCELERATION= .000G (HORIZ) .000G (VERT)
 SILT ELEVATION= 224.00FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 87.30FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(Feet)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	621.39	46.79	29076.88	8459.37
HEADWATER	276.26	30.62		
TAILWATER	40.44	11.99	484.74	17911.46
UPLIFT	356.79	50.20		38.18
SILT	5.73	6.67		
WATER LOAD	69.80	78.40	5472.32	
SILT LOAD	5.70	85.10	485.07	
DS WATER LOAD	6.60	3.40	22.44	
			*****	*****
			35541.43	26409.02

NET HORIZONTAL FORCE= 241.55 KIPS
 NET VERTICAL FORCE= 346.71 KIPS
 NET MOMENT= 9132.41 KIP-Feet
 X-BAR OF FOUNDATION REACTION= 26.34 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 17.31 FEET
 *****FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE*****TENSION AT HEEL OF DAM*****
 FOUNDATION REACTION PRESSURES*****TOE= 60.39 PSI*****HEEL= -5.23 PSI*****
 OVERTURNING FACTOR OF SAFETY= 1.35
 SLIDING FACTOR OF SAFETY= .86
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .70
 SLIDING WITH SHEAR FACTOR OF SAFETY= 3.46(SHEAR ACROSS FULL BASE WIDTH)

 GREEN LANE RESERVOIR DAM SPILLWAY SECTION
 NORMAL POOL WITH ICE LOADING

 BASE ELEVATION= 204.00FT. TOP ELEVATION= 286.00FT. BASE WIDTH= 87.30FT. DENSITY= 150.00PCF
 HEADWATER ELEVATION= 285.00FT. TAILWATER ELEVATION= 204.00FT. EARTHQUAKE ACCELERATION= .000G (HORIZ), .000G (VERT)
 SILT ELEVATION= 224.00FT. SILT DENSITY(SUBMERGED)= 80.00PCF SILT PRESSURE COEFFICIENT(K)= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 87.30FT. FRICTION FACTOR= .40

LOADING	FORCE(KIPS)	ARM(Feet)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	621.39	46.79	29076.88	
HEADWATER	204.70	26.97		5521.45
UPLIFT	220.62	58.20		12840.33
SILT	5.73	6.47		38.18
WATER LOAD	69.80	78.40	5472.32	
SILT LOAD	5.70	85.10	485.07	
ICE LOAD	5.00	81.50	407.50	
			*****	*****
			35441.76	18399.96

NET HORIZONTAL FORCE= 205.43 KIPS
 NET VERTICAL FORCE= 476.27 KIPS
 X-BAR OF FOUNDATION REACTION= 35.78 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 7.87 FEET
 FOUNDATION REACTION PRESSURES= 58.37 PSIHEEL= 17.40 PSI*****
 OVERTURNING FACTOR OF SAFETY= 1.93
 SLIDING FACTOR OF SAFETY= 1.39
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .43
 SLIDING WITH SHEAR FACTOR OF SAFETY= 4.45(SHEAR ACROSS FULL BASE WIDTH)

[illegible]

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NET HORIZONTAL FORCE= 236.77 KIPS
NET VERTICAL FORCE= 473.54 KIPS
NET MOMENT= 15610.24KIP-FEET
X-BAR OF FOUNDATION REACTION= 32.96 FEET
CENTRICITY OF FOUNDATION REACTION FROM CENTER= 10.49 FEET
FOUNDATION REACTION PRESSURES*****= 45.33 PSI*****HEEL= 10.01 PSI*****
OVERTURNING FACTOR OF SAFETY= 1.80
SLIDING FACTOR OF SAFETY= 1.20
DEVELOPED FRICTION FACTOR (NO SHEAR)= .50
SLIDING WITH SHEAR FACTOR OF SAFETY= 3.85(SHEAR ACROSS FULL BASE WIDTH)

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 GREEN LAKE RESERVOIR DAM NON-OVERFLOW SECTION
 NORMAL POOL USE = 286

 BASE ELEVATION= 204.00FT. TOP ELEVATION= 297.00FT. BASE WIDTH= 76.30FT. DENSITY= 150.00PCF
 HEADWATER ELEVATION= 286.00FT. TAILWATER ELEVATION= 204.00FT. EARTHQUAKE ACCELERATION= 0.000G (HORIZ), 0.000G (VERT)
 SILT ELEVATION= 224.00FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 76.30FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	535.08	49.06	27235.03	5728.48
HEADWATER	209.79	27.31		9929.46
UPLIFT	195.21	50.87		38.18
SILT	5.73	6.67		
WATER LOAD	14.20	74.40	1056.48	
SILT LOAD	1.20	75.80	90.96	
			*****	*****
			28382.46	15696.13

NET HORIZONTAL FORCE= 215.52 KIPS
 NET VERTICAL FORCE= 375.28 KIPS
 NET MOMENT= 12484.33KIP-Feet
 X-BAR OF FOUNDATION REACTION= 33.81 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 4.34 FEET
 FOUNDATION REACTION PRESSURES*****TOE= 45.83 PSI*****HEEL= 22.49 PSI*****
 OVERTURNING FACTOR OF SAFETY= 1.81
 SLIDING FACTOR OF SAFETY= 1.04
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .57
 SLIDING WITH SHEAR FACTOR OF SAFETY= 3.59(SHEAR ACROSS FULL BASE WIDTH)

 GREEN LANE RESERVOIR DAM NON-OVERFLOW SECTION
 PHF WITH TAILWATER

 BASE ELEVATION= 204.00FT. TOP ELEVATION= 297.00FT. BASE WIDTH= 76.30FT. DENSITY= 150.00PCF
 HEADWATER ELEVATION= 298.99FT. TAILWATER ELEVATION= 240.00FT. EARTHQUAKE ACCELERATION= 0.000G (HORIZ) 0.000G (VERT)
 SILT ELEVATION= 224.00FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 76.30FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(Feet)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	555.08	49.06	27235.03	
HEADWATER	281.40	31.64		8902.31
TAILWATER	40.44	11.99	484.74	
UPLIFT	311.83	43.88		13682.07
SILT	5.73	6.47		38.18
WATER LOAD	18.50	74.20	1372.70	
SILT LOAD	1.20	75.80	90.96	
			*****	*****
			29183.42	22622.56

NET HORIZONTAL FORCE= 246.69 KIPS
 NET VERTICAL FORCE= 262.95 KIPS
 NET MOMENT= 4560.84KIP-Feet
 X-BAR OF FOUNDATION REACTION= 24.95 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 13.20 FEET
 *****FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE*****TENSION AT HEEL OF DAM*****
 FOUNDATION REACTION PRESSURES*****TOE= 48.77 PSI*****HEEL= -.91 PSI*****
 OVERTURNING FACTOR OF SAFETY= 1.29
 SLIDING FACTOR OF SAFETY= .64
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .94
 SLIDING WITH SHEAR FACTOR OF SAFETY= 2.87(SHEAR ACROSS FULL BASE WIDTH)

 GREEN LANE RESERVOIR DAM NON-OVERFLOW SECTION
 NORMAL POOL WITH ICE LOADING

 BASE ELEVATION= 204.00FT. TOP ELEVATION= 277.00FT. BASE WIDTH= 76.30FT. DENSITY= 150.00PCF
 HEADWATER ELEVATION= 286.00FT. TAILWATER ELEVATION= 204.00FT. EARTHQUAKE ACCELERATION***.000G (HORIZ)***.000G (VERT)
 SILT ELEVATION= 224.00FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 76.30FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(Feet)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	555.08	49.06	27235.03	5728.48
HEADWATER	209.79	27.31		9929.46
UPLIFT	195.21	50.87		38.18
SILT	5.73	6.67		
WATER LOAD	14.20	74.40	1056.48	
SILT LOAD	1.20	75.80	90.96	
ICE LOAD	5.00	81.50	407.50	
			*****	*****
			28789.96	15696.13

 NET HORIZONTAL FORCE= 210.52 KIPS
 NET VERTICAL FORCE= 375.28 KIPS
 NET MOMENT= 13093.83KIP-Feet
 X-BAR OF FOUNDATION REACTION= 34.89 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 3.26 FEET
 FOUNDATION REACTION PRESSURES*****STOE= 42.91 PSI*****HEEL= 25.40 PSI*****
 OVERTURNING FACTOR OF SAFETY= 1.83
 SLIDING FACTOR OF SAFETY= 1.07
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .56
 SLIDING WITH SHEAR FACTOR OF SAFETY= 3.68(SHEAR ACROSS FULL BASE WIDTH)

 GREEN LANE RESERVOIR DAM NON-OVERFLOW SECTION
 GREEN LANE NORMAL POOL WITH EARTHQUAKE LOADING

 BASE ELEVATION= 204.00FT. TOP ELEVATION= 297.00FT. BASE WIDTH= 76.30FT. DENSITY= 150.00PCF
 HEADWATER ELEVATION= 286.00FT. TAILWATER ELEVATION= 204.00FT. EARTHQUAKE ACCELERATION= .025G (HORIZ) .000G (VERT)
 SILT ELEVATION= 224.00FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 87.30FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(Feet)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	555.08	49.06	27235.03	5728.48
HEADWATER	209.79	27.31		9929.46
UPLIFT	195.21	50.87		
EARTHQUAKE INDUCED LOADINGS				

INERTIA-WATER	5.72	32.80		187.46
HORIZONTAL INERTIA-DAM	13.88	33.00		457.87

SILT	5.73	6.67	1056.48	38.18
WATER LOAD	14.20	74.40	90.96	
SILT LOAD	1.20	75.80	*****	*****
			28382.46	16341.47

 NET HORIZONTAL FORCE= 235.11 KIPS
 NET VERTICAL FORCE= 375.28 KIPS
 NET MOMENT= 12040.99 KIP-Feet
 X-BAR OF FOUNDATION REACTION= 32.09 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 6.06 FEET
 FOUNDATION REACTION PRESSURES= 50.44 PSI
 OVERTURNING FACTOR OF SAFETY= 1.74
 SLIDING FACTOR OF SAFETY= .96
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .63
 SLIDING WITH KEYWAY SHEAR-FACTOR OF SAFETY= 3.63 (SHEAR ACROSS KEYWAY ONLY)
